

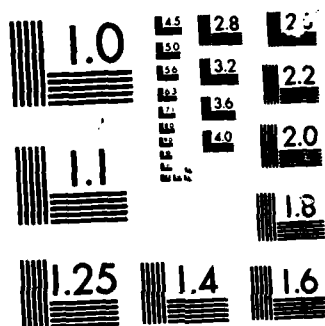
FEASIBILITY STUDY OF CONTAMINATION REMEDIATION AT NAVAL  
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# FEASIBILITY STUDY OF CONTAMINATION REMEDATION AT NAVAL WEAPONS STATION CONCORD, CALIFORNIA

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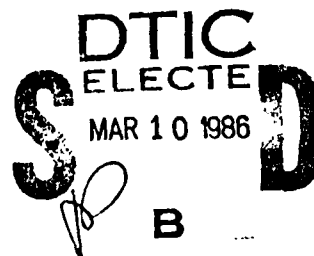
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Prepared for

DEPARTMENT OF THE NAVY  
Naval Facilities Engineering  
Command, Western Division  
San Bruno, California 94066

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report identifies and describes potential remedial actions to elimi- nate or mitigate the release of hazardous substances onto lands of the Naval Weapons Station Concord. Hazardous substances identified as necessitating remedial actions include lead, cadmium, zinc, copper, selenium, and arsenic. The proposed remedial actions are designed to address existing or potential damages identified in a separate study. These identified damages include: contamination of soil with metals; contamination and toxicity of plants and soil invertebrates; reduced plant growth; increased soil acidity; (Continued)		

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20. ABSTRACT (Continued).

surface water contamination; air contamination; losses of wildlife food quantity and quality of habitat; loss of wetland function; and loss of ultimate land use.

The release of hazardous substances at seven sites is identified. Sites include both wetland and upland habitat. The sites are consolidated into three areas based on the important nature of the habitat and category of remedial action that may be appropriate. Five categories of remedial actions were evaluated for implementation at NWS, Concord including: no action, increased environmental monitoring, source removal, source isolation, and site restoration.

Fourteen remedial action technologies were initially assessed with five technologies found to be applicable at NWS Concord. These five technologies were combined into ten alternative remedial actions. Seven alternatives survived the initial screening process and were subjected to a detailed evaluation using nine criteria: reliability, implementability, technical effectiveness, environmental concerns, safety, operation and maintenance, costs, regulatory requirements, and public acceptance.

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## PREFACE

This report presents the results of a comprehensive remedial action feasibility study at the Naval Weapons Station Concord, California.

This study was conducted at the U.S. Army Engineer Waterways Experiment Station (WES) by Mr. M. John Cullinane, Jr., Research Civil Engineer; Dr. C. R. Lee, Soil Scientist, and Chief, Contaminant Mobility and Regulatory Criteria Group; Ms. L. J. O'Neil, Wildlife Biologist and Ecologist; and Mr. E. J. Clairain, Jr., Aquatic Biologist, under the general supervision of Mr. D. L. Robey, Chief, Ecosystem Research and Simulation Division; Dr. C. Kirby, Chief, Environmental Resources Division; Dr. R. L. Montgomery, Chief, Environmental Engineering Division; and Dr. John Harrison, Chief, Environmental Laboratory.

Technical contributions in report preparation were received from the following WES scientists: Mr. J. G. Skogerboe, Hydrologist, for map presentation and Mr. Hollis Allen, for review of the wetland restoration plan. Technical contributions in report preparation were received from Dr. Gardner Brown, Chairman, Department of Economics, University of Washington, Seattle, WA, and Dr. Phil Sorenson, Professor, Department of Economics, Florida State University, Tallahassee, FL, for the cost evaluation portion of this report.

Peer review and constructive comments on the study and draft reports were received from Dr. K. D. Jenkins, Director, Molecular Ecology Institute, California State University, Long Beach, California; Dr. W. H. Patrick, Jr., Director, Center for the Wetland Resources, Louisiana State University Baton Rouge, La.; Dr. R. J. Kendall, Environmental Toxicological Services, Bellingham, Washington; Dr. R. K. Ringer, Professor of Physiology and Animal Science, Michigan State University, East Lansing, Michigan; Dr. S. A. Peoples, Retired, Professor Emeritus, Mammalian Toxicology, University of California, Davis, California; Dr. M. N. Josselyn, Director Tiburon Center for Environmental Studies, San Francisco State University, Tiburon, California; Dr. H. T. Harvey, Ecologist and President, Harvey and Stanley Associates Inc., Alviso, California; Dr. E. Meyers, Chemical Engineer, Meyer Consultants Inc., Lockport, Illinois, Dr. P. B. Williams, Hydraulic Engineer and Dr. R. N. Coats, Wildlife Resource Scientist, Philip Williams and Associates, San Francisco, California; and WES Scientists: Dr. R. K. Peddicord, Research Biologist, Dr. T. M. Dillon,

Aquatic Biologist, Dr. H. E. Tatem, Zoologist, Mr. V. A. McFarland, Aquatic Biologist, and Dr. R. N. Engler, Soil Scientist and Program Manager for Environmental Effects of Dredging Program.

Additional review and comments were received from Mr. R. M. Cornelius, Esq, and Mr. J. M. Robertson, Esq, Assistant General Counsel, Department of the Navy, Washington, D.C.; Mr. C. Schwab, Environmental Engineer, Western Division Naval Facilities Engineering Command, San Bruno, California and W. K. Vizza, Public Works Officer, Naval Weapons Station, Concord, California.

Director of WES during the preparation of this report was COL Allen F. Grum, CE. Technical Director was Dr. Robert W. Whalin.

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## TABLE OF CONTENTS

	<u>Page</u>
PREFACE . . . . .	1
1.0 EXECUTIVE SUMMARY . . . . .	1.1
2.0 INTRODUCTION . . . . .	2.1
2.1 Site Background Information . . . . .	2.1
2.1.1 Location . . . . .	2.1
2.1.2 Topography . . . . .	2.5
2.1.3 Climatology . . . . .	2.6
2.1.4 Geology . . . . .	2.6
2.1.5 Soils . . . . .	2.6
2.1.6 Surface Water Hydrology . . . . .	2.10
2.1.7 Groundwater Hydrology . . . . .	2.20
2.1.8 Land Use . . . . .	2.21
2.2 Nature and Extent of Problems . . . . .	2.23
2.2.1 Parcel 571 (Canal Pier 4) . . . . .	2.23
2.2.2 Parcel 572 (KS, AA, AB) . . . . .	2.24
2.2.3 Parcel 573 (K-2) . . . . .	2.24
2.2.4 Parcel 574 (K-2) . . . . .	2.24
2.2.5 Parcel 575 (G-1) . . . . .	2.31
2.2.6 Parcel 576 (ES) . . . . .	2.31
2.2.7 Parcel 579D (ES) . . . . .	2.31
2.2.8 Parcel 581 (CP) . . . . .	2.31
2.3 Previous Response Actions . . . . .	2.32
2.4 Statutes, Regulations, and Authorities . . . . .	2.34
3.0 CONTAMINATION ASSESSMENT . . . . .	3.1
3.1 Potential Contaminant Migration Pathways . . . . .	3.1
3.1.1 Air Pathway . . . . .	3.1
3.1.2 Surface Water Pathway . . . . .	3.4
3.1.3 Ground Water Pathway . . . . .	3.10
3.1.4 Biological Uptake and Accumulation . . . . .	3.11
3.1.5 Direct Exposure . . . . .	3.12
3.1.6 Summary . . . . .	3.12
3.2 Damage and Endangerment Scenarios . . . . .	3.13
3.3 Environmental Protection Goal . . . . .	3.13
4.0 EVALUATION OF THE NO ACTION ALTF NATIVE . . . . .	4.1

	<u>Page</u>
5.0 REMEDIAL ACTION OBJECTIVES AND GOALS . . . . .	5.1
5.1 Reliability . . . . .	5.1
5.2 Implementability . . . . .	5.2
5.3 Technical Effectiveness/Efficiency . . . . .	5.3
5.4 Environmental Concerns . . . . .	5.3
5.5 Safety Requirements . . . . .	5.4
5.6 Operation and Maintenance Requirements . . . . .	5.4
5.7 Cost . . . . .	5.5
5.8 Regulatory Requirements . . . . .	5.6
5.9 Public Acceptance . . . . .	5.7
6.0 SCREENING OF REMEDIAL ACTION TECHNOLOGIES . . . . .	6.1
6.1 Remediation Technologies . . . . .	6.1
6.1.1 Surface Sealing and Capping . . . . .	6.1
6.1.2 Grading and Revegetation . . . . .	6.3
6.1.3 Surface Water Diversion and/or Collection . . . . .	6.4
6.1.4 Containment Barriers . . . . .	6.5
6.1.5 Hydraulic Barriers . . . . .	6.5
6.1.6 Excavation and Disposal . . . . .	6.6
6.1.7 In Situ Treatment . . . . .	6.7
6.1.8 Bottom Sealing . . . . .	6.8
6.1.9 Groundwater and Leachate Treatment . . . . .	6.8
6.1.10 Incineration . . . . .	6.8
6.1.11 Withdrawal Well Networks . . . . .	6.9
6.1.12 Flood Proofing . . . . .	6.9
6.1.13 Permeable Treatment Beds . . . . .	6.9
6.1.14 Subsurface Collection Drains . . . . .	6.9
6.2 Summary of Applicable Technologies . . . . .	6.10
7.0 REMEDIAL ACTION ALTERNATIVES . . . . .	7.1
7.1 Alternative 1. No Action . . . . .	7.1
7.1.1 Alternative Description . . . . .	7.1
7.1.2 Implementation of Alternative 1 . . . . .	7.2
7.1.3 Environmental Effects . . . . .	7.2
7.1.4 Environmental Protection . . . . .	7.2

	<u>Page</u>
7.1.5 Implementability/Reliability . . . . .	7.2
7.1.6 Summary . . . . .	7.3
7.2 Alternative 2. Increased Environmental Monitoring . . . . .	7.3
7.2.1 Alternative Description . . . . .	7.3
7.2.2 Implementation of Alternative 2 . . . . .	7.4
7.2.3 Environmental Effects . . . . .	7.4
7.2.4 Environmental Protection . . . . .	7.4
7.2.5 Implementability/Reliability . . . . .	7.5
7.2.6 Summary . . . . .	7.5
7.3 Alternative 3. Source Removal . . . . .	7.5
7.3.1 Alternative Description . . . . .	7.5
7.3.1.1 Description of Alternative 3A . . . . .	7.7
7.3.1.2 Implementation of Alternative 3A . . . . .	7.7
7.3.1.3 Description of Alternative 3B . . . . .	7.10
7.3.1.4 Implementation of Alternative 3B . . . . .	7.11
7.3.1.5 Description of Alternative 3C . . . . .	7.13
7.3.1.6 Implementation of Alternative 3C . . . . .	7.13
7.3.1.7 Description of Alternative 3D . . . . .	7.14
7.3.1.8 Implementation of Alternative 3D . . . . .	7.14
7.3.2 Environmental Effects . . . . .	7.15
7.3.3 Environmental Protection . . . . .	7.16
7.3.4 Implementability/Reliability . . . . .	7.16
7.3.5 Summary . . . . .	7.17
7.4 Alternative 4. Source Isolation . . . . .	7.18
7.4.1 Alternative Description . . . . .	7.18
7.4.1.1 Description of Alternative 4A . . . . .	7.18
7.4.1.2 Implementation of Alternative 4A . . . . .	7.18
7.4.1.3 Description of Alternative 4B . . . . .	7.20
7.4.1.4 Implementation of Alternative 4B . . . . .	7.24
7.4.2 Environmental Effects . . . . .	7.24
7.4.3 Environmental Protection . . . . .	7.25
7.4.4 Implementability/Reliability . . . . .	7.25
7.4.5 Summary . . . . .	7.26

	<u>Page</u>
7.5 Alternative 5. Site Restoration . . . . .	7.26
7.5.1 Alternative Description . . . . .	7.26
7.5.1.1 Description of Alternative 5A . . . . .	7.27
7.5.1.2 Implementation of Alternative 5A . . . . .	7.28
7.5.1.3 Description of Alternative 5B . . . . .	7.28
7.5.1.4 Implementation of Alternative 5B . . . . .	7.30
7.5.1.5 Description of Alternative 5C . . . . .	7.33
7.5.1.6 Implementation of Alternative 5C . . . . .	7.33
7.5.2 Environmental Effects . . . . .	7.36
7.5.3 Environmental Protection . . . . .	7.36
7.5.4 Implementability/Reliability . . . . .	7.37
7.5.5 Summary . . . . .	7.37
8.0 ANALYSIS OF REMEDIAL ACTION ALTERNATIVES . . . . .	8.1
8.1 Non Cost Criteria Analysis . . . . .	8.1
8.1.1 Reliability . . . . .	8.1
8.1.2 Implementability . . . . .	8.3
8.1.3 Technical Effectiveness . . . . .	8.5
8.1.4 Environmental Concerns . . . . .	8.6
8.1.5 Safety . . . . .	8.8
8.1.6 Operation and Maintenance . . . . .	8.9
8.1.7 Regulatory Requirements . . . . .	8.11
8.1.8 Public Acceptance . . . . .	8.12
8.2 Cost Analysis . . . . .	8.13
8.2.1 Cost of Alternative 1 . . . . .	8.16
8.2.2 Cost of Alternative 2 . . . . .	8.16
8.2.3 Cost of Alternative 3A . . . . .	8.16
8.2.4 Cost of Alternative 4A . . . . .	8.16
8.2.5 Cost of Alternative 4B . . . . .	8.26
8.2.6 Cost of Alternative 5B . . . . .	8.26
8.2.7 Cost of Alternative 5C . . . . .	8.26
8.2.8 Summary of Costs . . . . .	8.26
9.0 SELECTION OF REMEDIAL ALTERNATIVE (To Be Published) . . . . .	9.1



	<u>Page</u>
10.0 ADDITIONAL STUDY REQUIREMENTS . . . . .	10.1
10.1 Alternative 1 . . . . .	10.1
10.2 Alternative 2 . . . . .	10.1
10.3 Alternative 3A . . . . .	10.1
10.4 Alternative 4A . . . . .	10.1
10.5 Alternative 4B . . . . .	10.2
10.6 Alternative 5B . . . . .	10.2
10.7 Alternative 5C . . . . .	10.2
11.0 REFERENCES . . . . .	11.1

## 1.0 EXECUTIVE SUMMARY

The Naval Weapons Station Concord, California (NWS Concord) is located in the North-Central portion of Contra Costa County in the San Francisco Bay Area of California. It is approximately 30 miles northeast of San Francisco and has, as part of its boundary, Suisun Bay on the north. The NWS Concord is bordered on the south and west by the City of Concord, which has a population slightly in excess of 100,000 residents. NWSC encompasses approximately 12,905 acres of land including both upland and wetland areas.

The Initial Assessment Study (IAS) conducted in accordance with the Navy Assessment and Control of Installation Pollutants (NACIP) program identified several areas requiring a Confirmation Study which in turn subsequently identified seven areas of contamination. A detailed comprehensive remedial investigation quantified contamination in these seven areas. Subsequent to the remedial investigation, a damage assessment identified the need for remedial action to prevent future environmental damage.

Contaminants of concern at the seven sites requiring remedial actions include: arsenic, cadmium, lead, copper, zinc, and selenium. Approximately 109.47 acres have been impacted by the contamination. Of these, approximately 54 acres require implementation of active remedial action technologies. The overall damaged area at NWS Concord is delineated in Figure 1.1 (Lee, et al. 1986). The extent of damage for each of the seven sites is summarized below:

<u>Area</u>	<u>Damage (acres)</u>
ES (parcel 579d)	1.41
(parcel 576)	0.63
G1 (parcel 575)	1.60
K2 (parcel 573)	3.77
(parcel 574)	2.79
KS (parcel 572)	8.15
AB (parcel 572)	8.68
AA (parcel 572)	20.75

<u>Area</u>	<u>Damage (acres)</u>
CP (parcel 581)	3.50
Canal Pier 4 (parcel 571) <sup>1</sup>	<u>2.43</u>
	53.71

<sup>1</sup> Pier 4 area contamination is not considered in this feasibility study.

Five categories of remedial actions were evaluated for implementation at the NWS Concord including: no action, increased environmental monitoring, source removal, source isolation, and site restoration. Fourteen remedial technologies were initially evaluated for applicability at the NWS Concord. Five technologies were found to be applicable and combined into ten alternative remedial actions for initial screening. Seven alternatives survived the initial screening process and were subjected to detailed evaluation.

Nine criteria were used to perform the detailed evaluation of each alternative. These criteria include: reliability, implementability, technical effectiveness, environmental concerns, safety, operation and maintenance, costs, regulatory requirements, and public acceptance. Using these criteria, it is possible to assess and identify the most appropriate alternative for implementation at NWS Concord.

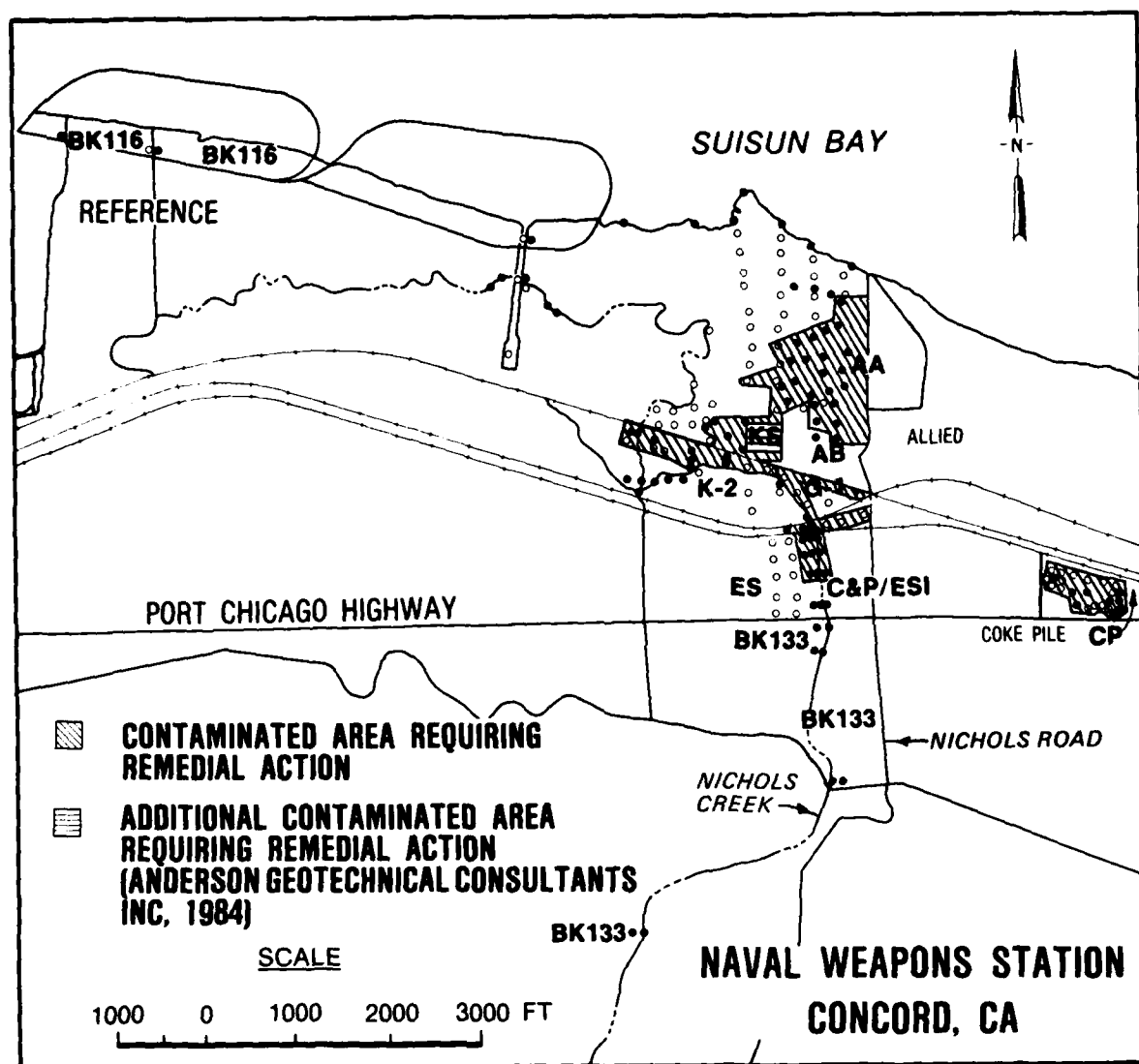


Figure 1.1. Overall areas of damage to natural resources at Naval Weapons Station Concord.

## 2.0 INTRODUCTION

This chapter of the Feasibility Study presents a brief overview of background information related to the NWS Concord. Section 2.1 discusses site background information including the location, topography, climatology, geology, soils, hydrology, and land use. Section 2.2 briefly discusses the nature and extent of contamination problems at NWS Concord. Section 2.3 discusses previous investigations and response actions at the site. The following documents are referenced for additional detailed background information concerning NWS Concord:

a. Ecology and Environment, Inc. 1983. "Initial Assessment Study of Naval Weapons Station, Concord, California," NEESA 13-013, Naval Energy and Environmental Support Activity, Port Huenene, California.

b. Anderson Geotechnical Consultants, Inc. 1984. "Confirmation Study Report 2 NWS Concord (Draft)," Department of the Navy, Naval Facilities Engineering Command, San Bruno, California.

c. Lee, et al. 1986. "Remedial Investigation of Contaminant Mobility at Naval Weapons Station, Concord (Final Report)," U. S. Army Engineer Waterways Experiment Station, Miscellaneous Paper EL-86-2, Vicksburg, Mississippi.

d. Lee, et al. 1985. "Assessment of Damage to Natural Resources at Naval Weapons Station, Concord (Preliminary Final Draft)," U.S. Army Engineer Waterways Experiment Station, Miscellaneous Paper EL-85- , Vicksburg, Mississippi.

### 2.1 Site Background Information

2.1.1 Location. NWS Concord is located in the north-central portion of Contra Costa County in the San Francisco Bay Area of California. The station is the major ammunition transshipment port on the west coast for the Department of the Navy. It is approximately 30 miles northeast of San Francisco and has, as part of its boundary, Suisun Bay on the north. The station is bordered on

the south and west by the City of Concord, which has a population slightly in excess of 100,000 residents.

NWS Concord encompasses over 12,922 acres of land consisting of three land holdings: the tidal influenced and inland areas (Figure 2.1) near the City of Concord, linked by a narrow Navy-owned rail and road corridor, and a radiography facility located at Pittsburg, California. This Feasibility Study includes the wetland, transition, and upland contaminated areas located near the city of Concord. Remedial actions required in the canal adjacent to pier 4, however, are not considered in this study but should be formulated after additional sampling and chemical analyses are performed in this area.

The Tidal Area is divided between mainland and islands as shown in Table 2.1. All but a few hundred of the approximately 7,630 acres are covered by the Explosive Quantity-Distance Separation Arcs generated by the three explosives handling piers. The piers and almost all of the other facilities in the Tidal Area are located on the original property of the Naval Magazine, Port Chicago. Other facilities include a barge pier, a 525-rail car barricaded siding complex, two rail holding yards, facilities for ammunition segregation and transfer, and warehouses and support buildings. Navy-owned Tidal Area property includes six islands in Suisun Bay: Freeman, Ryer, Snag, and Roe islands, and the two islets which make up the Seal Islands. These islands account for a total of 1,571 acres. Approximately 3,233 acres in the Tidal Area are leased out for agricultural purposes. Seven hundred and forty acres on the offshore islands are leased to duck hunting clubs.

The Inland Area, which is separated from the Tidal Area by a range of hills not owned by the Navy, encompasses approximately 6,208 acres. A Navy-owned road and rail line link the two areas. Almost 85% of the Inland Area is covered by Explosive Quantity-Distance Separation Arcs generated by a number of storage magazines and production facilities. Three roads cross the Inland Area: State Route 4, Willow Pass Road, and Bailey Road. The Contra Costa Canal also crosses the Inland Area. The largest single land use is ammunition storage, which is accommodated in five magazine groups and two groups of barricaded railroad sidings. Various production facilities, a Weapons Quality Engineering Center (WQEC), and the station's administrative complex are also

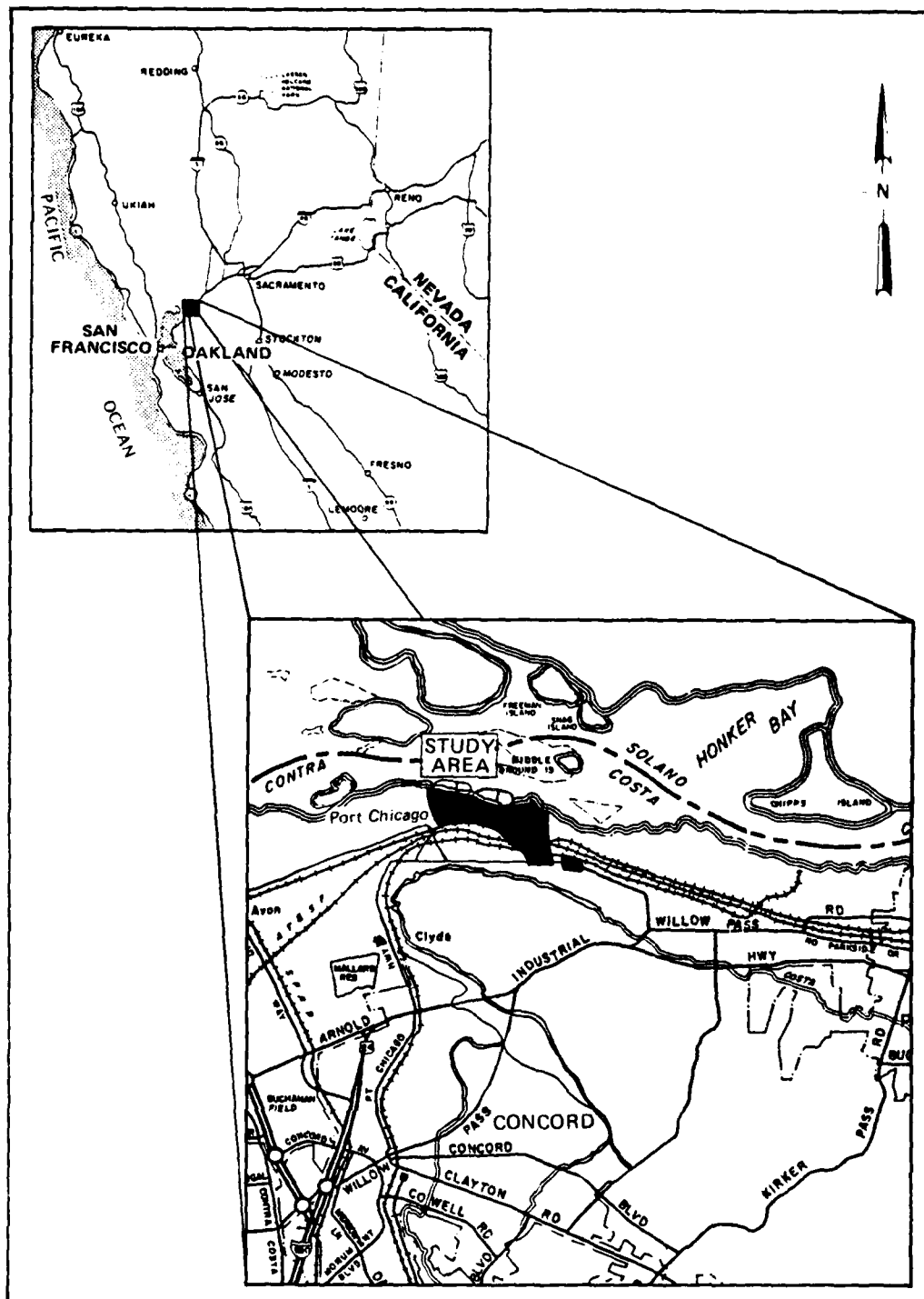


Figure 2.1. NWS Concord, Inland and Tidal Areas

Table 2.1

NWS CONCORD  
ACREAGE SUMMARY

Description	Area (acres)	Total Area (acres)
NWS CONCORD		<u>12,904.55</u>
CONCORD TIDAL AREA		7,630.56
Mainland	6,059.56	
Islands	1,571.00	
CONCORD INLAND AREA		5,272.31
Operations/Support/Storage	5,213.41	
Naval Reserve Training Facility	.55	
Connecting Roads to Tidal Area	27.70	
Housing Area (Officers and Enlisted)	30.65	
Explosive Quantity-Distance		
Separation Area	935.76*	
Pittsburg Radiography Facility		1.68

\*Not included in total

Source: Naval Facilities Engineering Command, Western Division,  
October 1979, NWS Concord Master Plan.



located in the Inland Area. In addition, the station maintains restrictive easements on land in the hills to the east.

The radiography facility located approximately six miles east of the Tidal Area at Pittsburg, California, encompasses 3.34 acres of property. The facility was part of the former United States Army Pacific Ordnance Steel Foundry. NWS Concord has title to 1.68 acres of the property; the remaining 1.24 acres are an easement from the United States Steel Corporation for an access road. The facility is similar to the WQEC X-ray facility located in the Inland Area. The radiographic facility is not considered in this study.

2.1.2 Topography. Station elevations range from slightly below sea level in the Tidal Area to ridges of nearly 800 feet along the northern boundary of the Inland Area. Originally, the Tidal Area consisted of three distinct land formations: salt marshes along the shore of the Suisun Bay, upland colluvial slope, and sandstone hills. A large section of the marshland was modified when the original weapons station was constructed by adding large amounts of fill material. Almost all existing tidal facilities were built on these fill areas. The former city of Port Chicago was located in an area of higher elevation and gentle slope designated as colluvial slope. The area to the south of Contra Costa Canal is characterized by steeply sloping terrain, beginning with a 100-foot elevation and rising to over 600 feet. The hills are composed of soft sandstone which is poorly suited for construction.

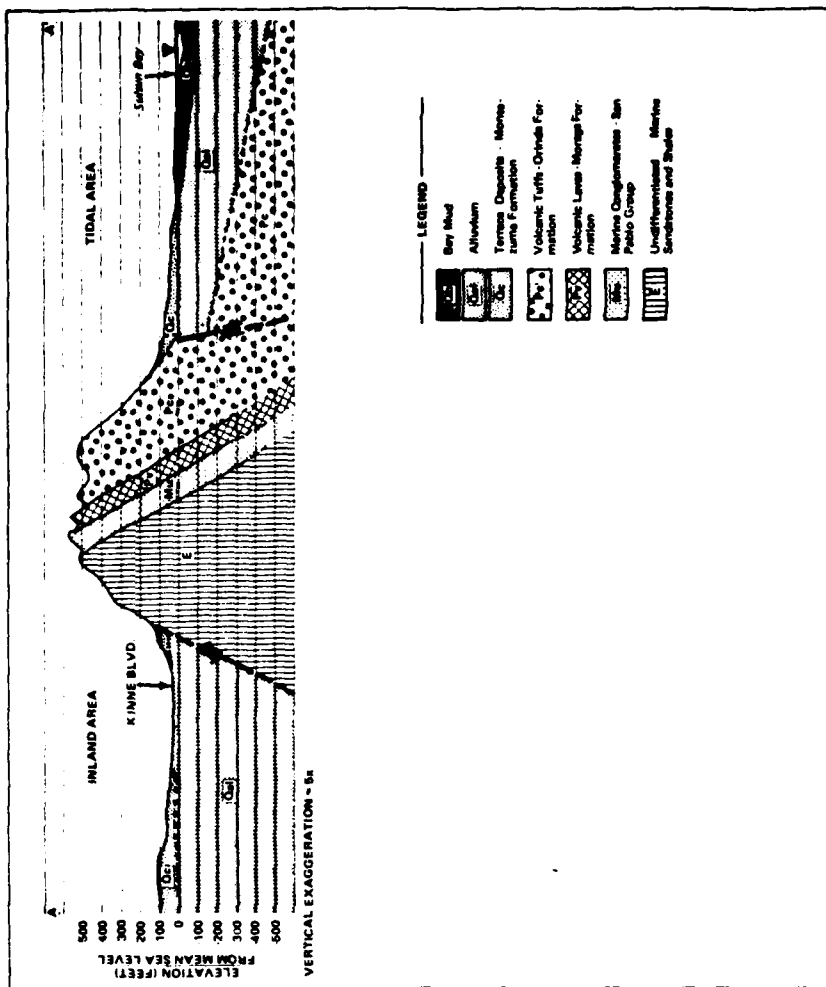
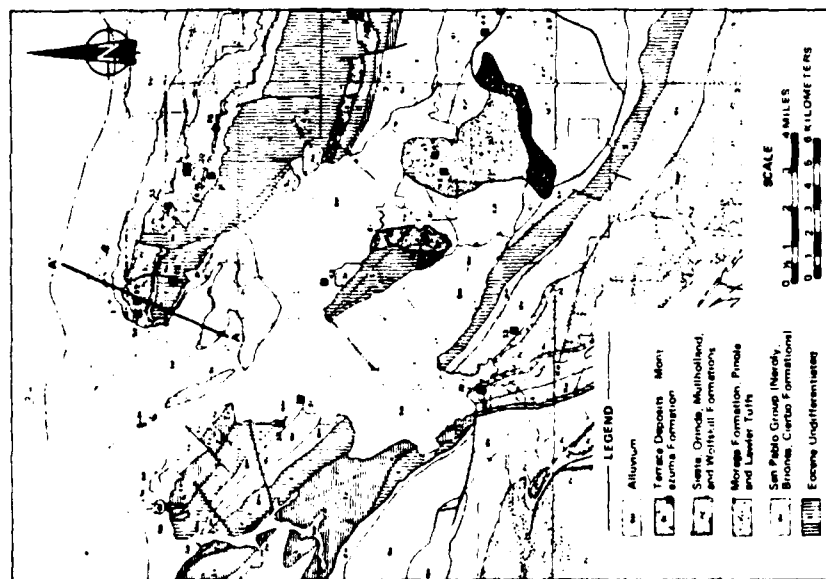
Included in the acreage for the Tidal Area are four islands (Freeman, Roe, Ryer, and Snag) located in Suisun Bay directly to the north of the shipping channel and two islands (Seal Islands) above the barge pier. The islands are covered by Explosive Quantity-Distance Separation Arcs and were acquired along with the two-mile buffer zone which forms the rest of the Tidal Area. Physically, they are similar to the salt marsh areas discussed above.

The Inland Area is similar in character to the central and higher portions of the Tidal Area. Gently sloping land extends through most of the western half of the Inland Area, while the tidal hills extend south and form the eastern boundary of the station.

2.1.3 Climatology. The mean annual precipitation for NWS Concord is 15.4 inches (Lee et al 1986). As in most of northern California, about 84% of the rainfall occurs from November through March. The climate in this area is characterized by westerly winds coming through the wind gap formed by the San Francisco Bay and Carquinez Strait. Particularly dominant during the summer months, these westerly winds are minimal from November through February. Occasionally, the late spring and summer weather is influenced by a high pressure ridge over the interior of California, with resulting high temperatures. The average temperature varies from 45°F in January to 75°F in August. In 1960, a high of 106°F in August and a low of 17°F in January were recorded. During the hard freeze of December 1972, the recorded low was 16°F.

2.1.4 Geology. Figure 2.2 is a geological map of NWS Concord with a cross-sectional depiction of the structure of the major geological formations. The up-thrusted bedrock feature which topographically separates the Inland and Tidal Areas is typical of the geology of Contra Costa County, where northwest trending fault systems such as the major, active Antioch, Concord, and Pleasanton faults divide the county into large up-and-down-thrown blocks of Tertiary-age rock. Over 200 earthquakes have been reported in Contra Costa County since 1934. The up-thrown blocks form the hills and the down-thrown blocks form the valleys. Unconsolidated Pleistocene-age alluvial sediments eroded from the up-thrown blocks partially fill the down-thrown valleys, often accumulating in thicknesses exceeding 500 feet.

2.1.5 Soils. The following discussion is extracted from Lee et. al (1986). The marsh and adjacent uplands at NWS Concord are formed from alluvium of three different ages and modes of deposition. At the mouths of canyons and footslopes are terrace remnants of Pleistocene alluvial fans and flood-plain deposits, consisting of irregularly interstratified sand, gravel, silt and clay (Qoa). The Pleistocene deposits are overlain by Holocene flood-plain deposits (Qa) consisting of irregularly interstratified sand, silt, gravel and clay. These are overlain at the margin of the Bay by bay mud (Qbm), consisting of unconsolidated silt and clay with admixed organic material. The Pleistocene and Holocene alluvial deposits are up to 500 feet thick and comprise a locally important aquifer with highly variable permeability.



SOURCE Adapted from Contra Costa County - Geologic Map Showing Mines, Quarries, and Gas Wells, 1988, California Division of Mines and Geology.

Figure 2.2. Geologic map of NWS Concord.

Most of the alluvium underlying the marsh was deposited when sea level was lower than present day. As the base level rose, the alluvial fans at the mouth of Nichols Creek and nearby tributaries accumulated to higher levels, were reworked and in places covered with flood-plain deposits by the Sacramento River. As the rate of sea level rise decreased, the present marsh deposits of peat and fine-grained alluvium began to accumulate.

An important feature of the marsh at the bay margin is the tidal drainage pattern, which is orientated parallel to the shoreline. Wave action at the shoreline builds up debris and sediment slightly higher than the elevation of the rest of the marshy plain. This prevents direct tidal drainage into Suisun Bay. The relative low density of tributary slough channels is another noteworthy feature of the marsh.

The USDA Soil Conservation Service Soil Survey Report (1978) identifies those soil series found on the site. The marsh soils are identified as Joice Muck series. In the system of the National Cooperative Soil Survey these marsh soils are clastic, euic, thermic Terric Medisaprists. The upland soils (on terrace deposits of alluvium) are classed as Antioch loam (fine, montmorillonitic, thermic Typic Natrixeralfs) or Capay clay (fine, montmorillonitic, thermic Typic chromoxererts). The soil survey map for the site is shown in Figure 2.3. It appears that the AA and KS areas on Parcel 572 were incorrectly mapped as AdC (Antioch loam), probably because of their light appearance on aerial photographs.

The shoreline at the bayward edge of the marsh is in a dynamic state, having undergone both erosion and recent deposition (Lee et al 1986). Sawn boards and other debris of human origins are exposed in the eroding bank at the marsh margin. Wind-generated waves play an important role in both shoreline erosion and during extreme tides, in the erosion of exposed sediment on the marsh plain.

Aside from shoreline erosion and deposition, three other significant long-term hydrologic trends influence the site. First, the sea level is rising at a rate of about 0.5 ft per hundred years. This is expected to continue at an increasing rate due to global climatic changes (EPA 1983). The high tide of



Figure 2.3. Soil survey map for NWS Concord Tidal Area

December 1983 was the highest tide ever recorded, and now forms the basis for the estimate of the "100-year high tide" (U.S. Army Corps of Engineers 1984). Second, hydraulic mining in the Sierra Nevada during the last century substantially increased the sediment input to the Bay-Delta system, resulting in extensive shoaling and filling of intertidal areas. Third, grazing in upland areas adjacent to NWS Concord has doubtlessly increased the sediment yield of streams discharging into the marsh.

2.1.6 Surface Water Hydrology. Surface water hydrology in the area covered by this study is characterized by both stream and tidal influences. The following discussion of the surface water hydrology is extracted from Lee et. al (1986).

The contaminated area is traversed by a small stream (which will be called Nichols Creek) that originates in the hills south of the study site (Fig. 2.4). The watershed area for this creek is slightly over one square mile. North of Port Chicago Highway the stream runs adjacent to the Chemical and Pigment Company plant, under two railroad right-of-ways (the Sacramento Northern and AT & SF tracks), under one unpaved road, and finally under a Southern Pacific railroad trestle into the salt marsh area. A second stream (which will be called the tributary stream) from a watershed west of Nichols Creek joins Nichols Creek just before passing under the railroad trestle into the salt marsh area.

Two methods are used for estimating short duration rainfall events and peak discharges for the watersheds draining through the study site. First, recording raingage data are available at Martinez (about 10 miles west of the site) for short duration events. These can be converted to data for Port Chicago by multiplying by 0.716, the ratio of the one day precipitation at Port Chicago to the one day precipitation at Martinez. These short duration data can be used to estimate peak discharges using the rational method. A second method for predicting peak discharges is based on streamflow records and is available in Waananen and Crippen (1977). This method uses equations relating flood magnitudes of selected frequency to basin characteristics such as drainage area, precipitation, and altitudes for six regions of California.

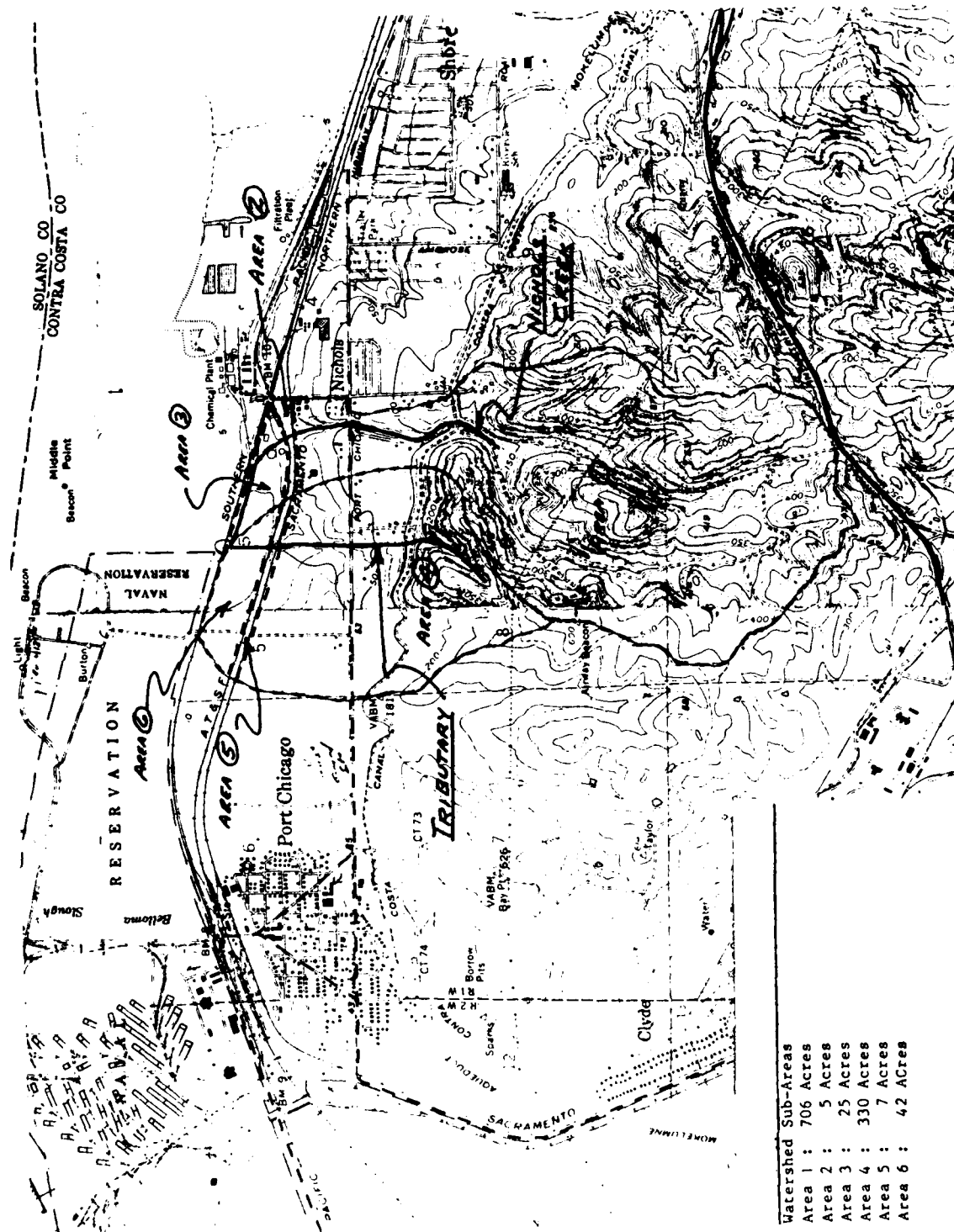


Figure 2.4. Drainage basins of Nichols Creek and tributary

Both methods have been used to estimate the peak discharge for the watershed areas flowing through the contaminated area. The two methods predict approximately the same peak discharge for recurrence intervals of 50 years, but the method of Waananen and Crippen predicts a lower discharge for recurrence intervals less than 50 years. It is thought that the method of Waananen and Crippen may be more accurate, but calculations made by both methods are presented in Table 2.2.

Between the Port Chicago Highway and the marsh where Nichols Creek terminates, the stream channel is full of a dense stand of cattail (Typha angustifolia). Adjacent to the Chemical and Pigment Company the channel also supports a luxuriant growth of watercress (Nasturtium sp.).

The stream must pass through culverts under the Port Chicago Highway, under the two railroads and under the unpaved road. Some of these culverts are at present largely blocked with sediment and some may be too small to allow peak discharges of major storms to pass without ponding. Any ponding behind the culverts may represent a control on the actual peak discharges passing down the stream bed to the trestle where it discharges into the marsh.

Water which backs up behind the culverts under the railroad tracks would form a reservoir upstream, but water blocked by the single small culvert under the unpaved road north of the AT & SF tracks on Parcel 575 (G-1 area) would increase in depth until it flowed over the road. From the road much of the overflow could flow in the right overbank area of the stream bed (G-1 area), down the hill and into the ditch which runs beside the Southern Pacific Tracks (North of G-1 area). This possibility will be discussed in more detail in section 3.1.2.1.

The present course of Nichols Creek is quite different from its original course. The pre-railroad survey of 1866 (T1029) shows Nichols Creek entering the marsh at approximately the Kiln Site, with a "bulge" in the contours that suggests a small fan in the marsh at the mouth of the creek. When the railroad was built in the late 1860s, a stream crossing was apparently installed. It is unclear how long this structure functioned effectively. Aerial photography, dated 1939 and 1959, shows the creek passing under the SP track through



Table 2.2. Discharge in Nichols Creek  
and Tributary

Recurrence Interval	Discharge Calculated by Rational Method (in CFS)			Discharge Calculated by Method in Waananen and Crippen (1977) (in CFS)		
	Nichols Creek*	Tributary **	Total	Nichols Creek*	Tributary **	Total
2	136	70	206	40	19	59
5	188	97	285	94	47	141
10	225	115	340	145	74	219
20	260	133	393			
25	271	139	410	223	116	339
40	289	149	438			
50	306	158	464	292	154	446
100	335	173	508	369	197	566
200	364	188	552			

\* Nichols Creek discharge includes precipitation from watershed areas 1, 2, and 3 of Fig. 2.4.

\*\* Tributary discharge includes precipitation from watershed areas 4, 5, and 6 of Fig. 2.4.

the culvert. It appears from available air photos that at some time during the 1960's Nichols creek was diverted to flow on the south side of the Southern Pacific tracks to the trestle where it now terminates. This diversion was accomplished by filling the stream channel into the culverts and building up a small berm along the south side of the Southern Pacific tracks, which kept the creek constrained to its new channel running through the K-2 area to the trestle. A curious depression (about 50 feet east of the culverts) that appears to have resulted from a cave-in marks what could be the old channel. The culverts under the Southern Pacific tracks (twin 32" CMP) are at present half-filled with sediment, and now receive drainage only from the ditch on the south side of the tracks east of the culverts. Old maps from 1886 (T1793) show cultivated fields north of the Southern Pacific track below the culvert.

In addition to the flowing stream hydrology, the study area is also influenced by tidal action. The following discussion of tidal influences in the study area is extracted from Lee et al (1986).

Table 2.3 shows heights of high and low tides (NGVD datum) at Middle Point. These are based on interpolation between tidal stations at Port Chicago and Mallard Island Ferry wharf, about one mile to the east.

In order to derive the curve for duration of tidal height at Middle Point, it was necessary to use the established curve for Ft. Point (San Francisco) and adjust for local conditions. First, the normalized curve (Harris, 1981) was multiplied by 1/2 the mean diurnal range at the site. This curve is based on predicted astronomical tides. Assuming that the Mean High Water (MHW) and Mean Higher Water (MHHW) are equalled or exceeded at Ft. Point and Middle Point for the same percentage of the time, the curve was then adjusted to fit local MHW and MHHW. Fig. 2.5 is the adjusted curve.

The duration and frequency of tide heights in the marsh, however, differ from that in the bay. In order to establish the relationship, staff gages and stage level recorders were installed in sloughs and ditches at four locations. These locations are shown on Fig. 2.6. Gage #1 is at the slough mouth, near Pier 4. Gage #2 is in about the middle of the marsh, 100 ft northwest of survey control point No. 11. Gage #3 is near the upper end of the eastern area

Table 2.3  
Tidal Elevations near NWS.  
Elevations are in ft.

	Port Chicago		Allied		Mallard Is.	
	MLLW	NGVD	MLLW	NGVD	MLLW	NGVD
MHHW	4.7	3.02	4.4	2.90	4.0	2.80
MHW	4.15	2.47	3.8	2.3	3.45	2.25
MTL	2.4	0.72	2.2	0.7	2.0	0.8
1929 MSL	1.68	0	1.55	0	1.20	0
MLW	0.65	-1.03	0.60	-0.9	0.55	-0.65
MLLW	0	-1.68	0	-1.5	0	-1.20
Mean Range		3.5		3.2		2.9
Mean Diurnal Range		4.7		4.4		4.0
Relation to Ft. Point, San Francisco						
Time (hrs)						
high	+2:36		+2:59		+3:26	
low	+3:08		+3:33		+4:03	
Ht						
high	-1.0		-1.3		-1.7	
low	-0.4		-0.45		-0.5	

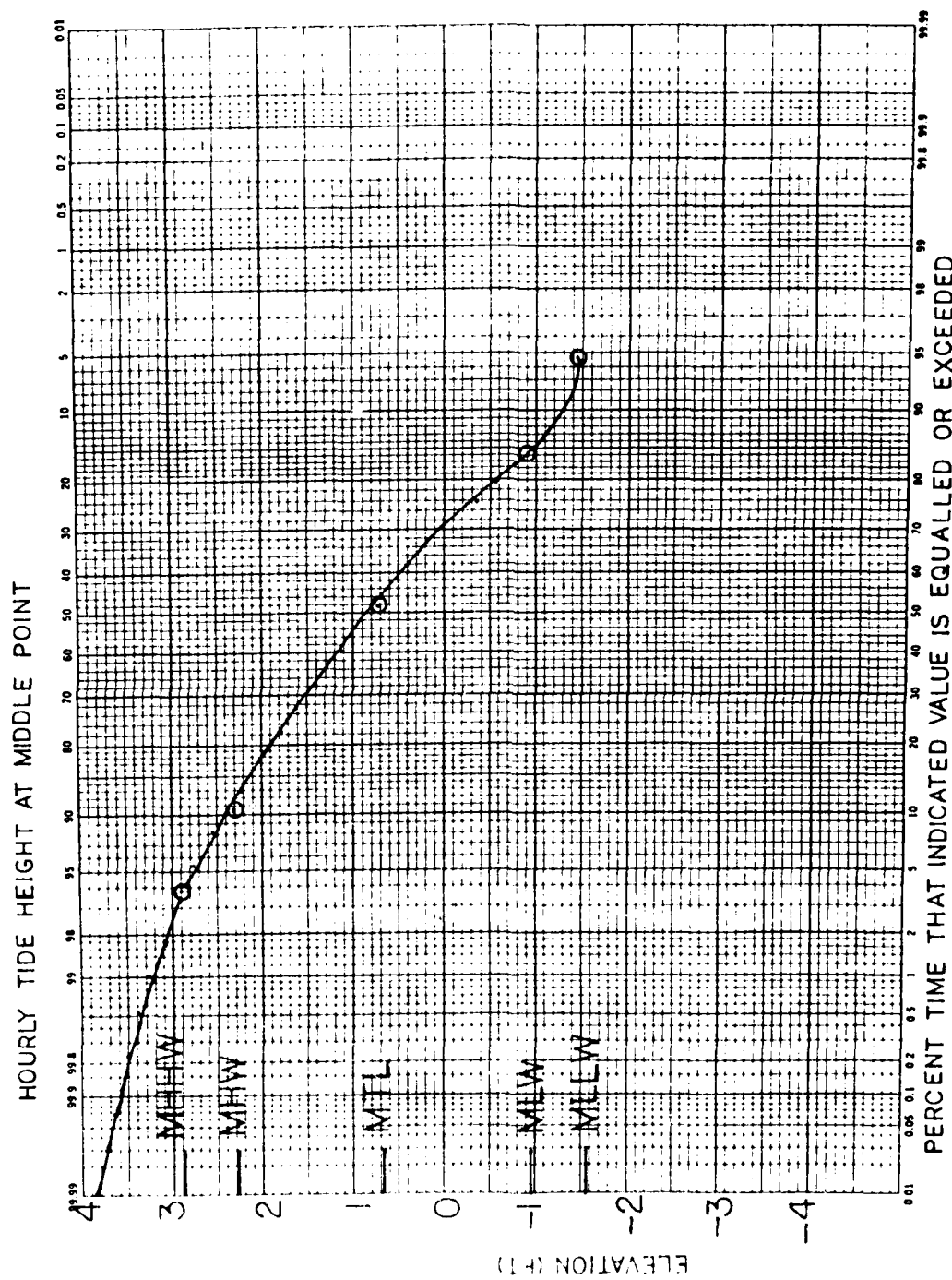


Figure 2.5. Duration of tide height at Middle Point

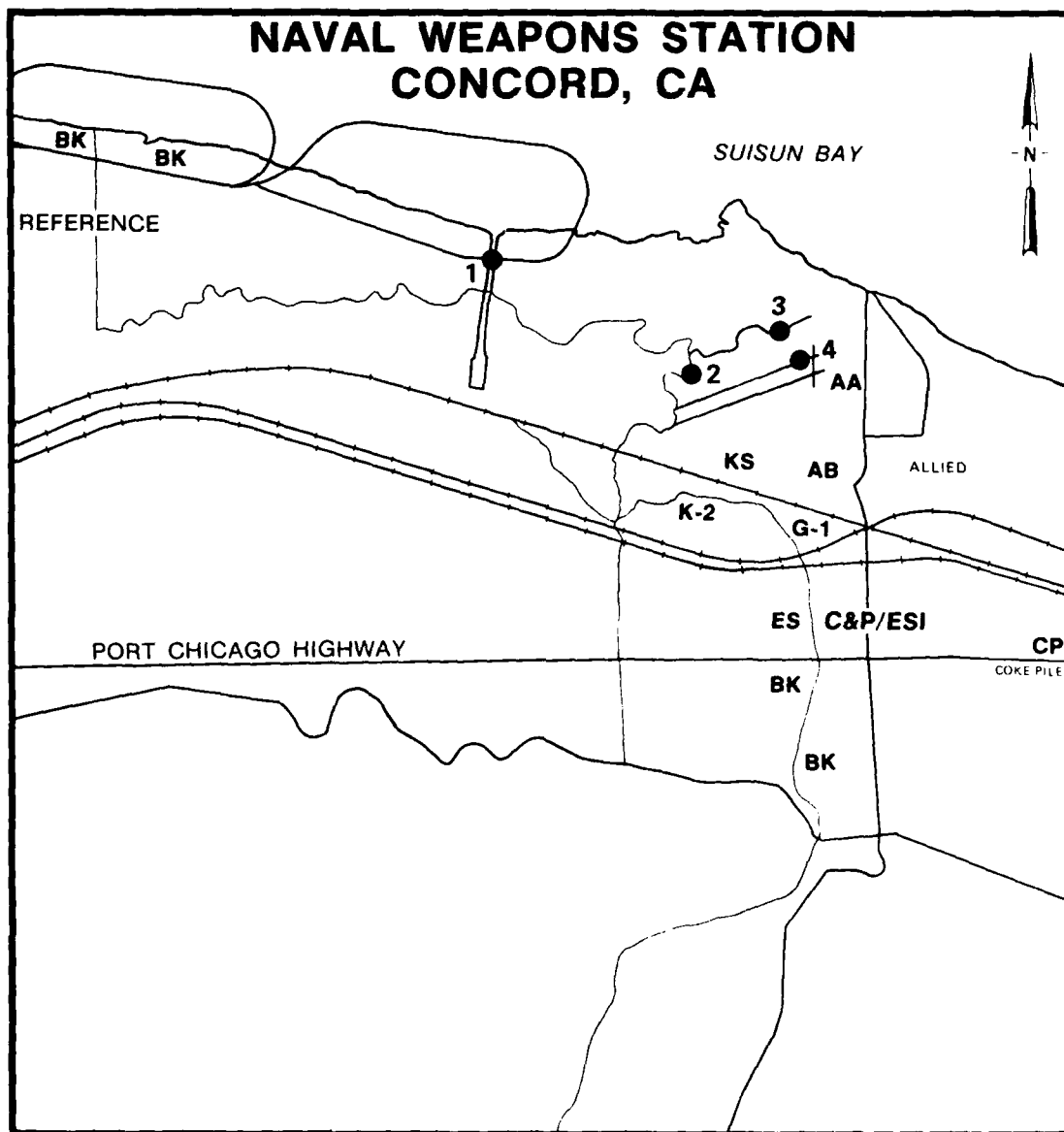


Figure 2.6. Tide staff gage locations on Parcels 571 and 572 at Naval Weapons Station Concord

of the slough, and Gage IV is in a mosquito ditch about 450 ft west of the dike, in area AA. Gages #1 and #2 were surveyed by differential leveling from bench marks established by Towill, Inc., with one instrument setup each. Gages #3 and #4 were surveyed from a Coast and Geodetic Bench Mark at the Allied Plant. Closure error was 0.03 ft, and this error was distributed. The elevations of 4 spring higher high tides were then read at each location (Table 2.4). The data indicate that high tides are slightly attenuated (about 0.6 ft) as the tidal wave moves up the slough into the marsh, and that most of the attenuation occurs in the lower half of the slough channel.

A fifth gage was placed at control point No. 11 (elev. 3.10). The tides of June 2nd and 3rd recorded elevations of 3.46 and 3.55 just 100 ft away, but the vegetation on the marsh plain (mostly salt grass here) prevented water from flowing over the surface to the control point. The soil, however, was moist on the days following the high tides.

Because vegetation has such a retarding effect on tides that just barely flood the marsh plain, it is not feasible to draw an accurate map on tidal inundation frequency using just topographic information. It is possible, however, to infer something about the extent and frequency of tidal flooding for different portions of the marsh. Table 2.5 shows the frequency and duration of tide height for different areas of the marsh. Mean Higher High Water is equalled or exceeded 3 percent of the time, or 123 times per year. Such a tide fills sloughs and ditches in the marsh to within about 0.5 ft of the bank top. The ditches and sloughs are completely filled by a high tide that is equalled or exceeded about 52 times per year, or 15% of the time. High tides of 3.6 - 3.8 ft NGVD at the slough mouth are equalled or exceeded 0.1 to 0.01 percent of the time (7.4 to 1.3 times per year) and result in maximum water elevations in the upper marsh of 3.2 to 3.4 ft. These tides flood the depressions in the marsh plain near sloughs and ditches, but areas remote from sloughs with dense vegetation are moistened but not inundated.

As a result of the record high tides of 1983, the Army Corps of Engineers undertook a new 100-yr high tide study (Army Corps of Engineers 1984). The 10-yr and 100-yr high tide elevations from that study are also shown in Table 2.5. They represent a different statistical distribution than the

Table 2.4  
Maximum Tide Height at Staff Gages in NWS Marsh

Gage No.	Max. tide height, ft NGVD			
	June 2	June 3	June 19	July 2
1	3.81	3.92	3.81	3.99
2	3.46	3.55	3.52	3.55
3	3.42	3.54	3.50	3.50
4	--	3.33	3.32	3.31

Table 2.5  
Tidal duration and frequency for NWS marsh, based on adjusted curve  
for Ft. Point and staff gage readings in the marsh

Tide	Duration (%hours)	Frequency (Higher Highs)	Times per yr	slough mouth	mid slough	upper slough
MHHW	3%	.35	123	2.90	2.55	2.51
	15%	.146	51.5	3.30	2.95	2.91
	0.1%	.021	7.4	3.60	3.25	3.21
	0.01%	.0037	1.3	3.80	3.45	3.41
10-year high tide	---	$2.8 \times 10^{-4}$	0.1	5.7	5.35*	5.31*
100-year high tide	---	$2.8 \times 10^{-5}$	.01	6.2	5.85*	5.81*

\* These elevations are based on the questionable assumption that extreme high tides are attenuated as much as more frequent high tides. The actual extreme high tide elevations probably are not much different from the elevations at the slough mouth.

predicted astronomical tides because they reflect actual measurements of storm surges during high tides.

The 10-year and 100-year high tides reach elevations of 5.7 and 6.2 ft NGVD respectively, at the slough mouth. These tides are not attenuated by slough channels and marsh vegetation as somewhat lower tides. Consequently, the 10-year high tide would completely inundate the marsh plain (including the area AA on Parcel 572), lapping against the dike and railroad embankments, and covering part of the contaminated KS area on Parcel 572. This tide would reach under the trussel of the Southern Pacific tracks and inundate the lower portion of the contaminated K-2 area on Parcel 573 above the Southern Pacific tracks.

Three major manmade alterations to the natural tidal influences have been implemented. The first alteration of tidal drainage occurred sometime after 1888, and probably in the early 20th century. Channels were dredged southward from the shoreline, and the naturally occurring slough channels connected to these. This probably increased tidal action in the marsh, resulting in higher highs and lower lows of tidal range. The second alteration of the local tidal drainage pattern occurred in or prior to 1959 when the local mosquito abatement district excavated a network of ditches in the marsh to improve drainage. These have been cleared out subsequently, and substantially increase the circulation of tidal water through the marsh. The third alteration of marsh drainage occurred as a result of the overflow from the Allied Chemical waste lagoon in area AA. This flow of waste lagoon sludge over the marsh plain raised the elevation locally, and filled the heads of the natural slough channels.

2.1.7 Groundwater Hydrology. There are moderate amounts of groundwater on the NWS Concord, both in the unconsolidated formations and the bedrock. However, satisfactory yields can generally be obtained only by drilling deeper bedrock wells. Until the early 1960s, NWS Concord obtained its water supply from three 500-foot-deep wells. However, at that time, the wells were shut down and NWS Concord, as is the case with nearly all Bay Area communities, now derives its water supply from surface sources.



Groundwater quality is generally only fair. Total dissolved solids, hardness, chlorides, and iron concentrations are relatively high, especially when compared to available surface water in the area.

Some wells are still used for water supply. In particular, with respect to NWS Concord, these include several wells in the industrial complex area to the west, used primarily for process water and cooling water, and a series of wells surrounding Mallard Reservoir, also to the west. The owner of the Mallard Reservoir, the Contra Costa County Water District, uses the groundwater to augment the normal aqueduct supplies of drinking water to the reservoir during droughts.

2.1.8 Land Use. Suisun Bay and a conglomerate of islands containing marshlands and numerous man-made levees are located to the north of the Tidal Area. As mentioned previously, Ryer, Roe, Freeman, Snag, and Seal islands are a part of the NWS Concord landholdings. Portions of these islands are leased to duck hunting clubs. The other islands in this area are privately owned and managed as a wetland system by the Suisun Marsh Conservatory. Recreational activities, such as duck hunting and fishing, constitute the major land use in this area, although farther to the north, portions of the islands are used for growing specialty crops, such as asparagus.

Within the Tidal Area there is a privately owned parcel of land which belongs to three chemical companies: the Allied Chemical Corporation, the Collier Carbon and Chemical Corporation, and the Chemical and Pigments Company. The Collier plant is no longer in operation, and the Navy is considering acquiring the 17.6 acres occupied by the plant. The Allied Chemical plant is engaged primarily in the manufacture of aluminum sulfate, sulfuric acid, hydrofluoric acid, nitric acid, and acetic acid. The Chemical and Pigment Company is involved in the manufacture of inorganic chemicals. There have been incidents in the past of contamination of NWS Concord lands by activities of these chemical companies.

Three railroads, the Santa Fe, the Southern Pacific, and the Sacramento Northern, own rights-of-way which bisect the Tidal Area. The Port Chicago Highway and the Waterfront Road, both county owned roads, and the Contra Costa Canal

complete the list of non-Navy controlled land uses within the NWS Concord Tidal Area.

Land to the east of the Tidal Area is sparsely developed, with only a small residential area named Shore Acres and the McAvoy boat harbor. Oil refineries are located farther to the east, adjacent to the Suisun Bay in the City of Pittsburg.

The hills which separate the Tidal and Inland Areas are the site of the Los Medanos underground gas storage field. This land is privately owned and is leased to the Pacific Gas and Electric Company for deep well gas injection. The land is also used for cattle grazing. Located 15 miles to the southeast of the station is the Mt. Diablo State Park and State Game Refuge. This 7,004-acre preserve contains picnic facilities, campsites, and hiking trails.

The station is bordered on the south by the residential sections of the City of Concord. These neighborhoods are made up of single-family, medium-density housing. Most of the housing dates from the mid-1950s. In addition, seven public schools and several parks parallel the Navy property line. Steep slopes and access problems have prevented extensive development along Kirker Pass Road and in the hills northeast of the NWS Concord. These areas are still zoned for open space and agricultural land uses. A recent exception to this is the Concord Pavilion, which was constructed on Kirker Road near the station boundary.

The Concord Municipal Golf Course occupies a triangular parcel of land between State Route 4, the Port Chicago Highway, and the station's administration/support complex. The golf course is partially on 65.88 acres of city land and partially on a 103.12-acre tract of leased NWS Concord land.

To the north of Route 4 and to the west of NWS Concord, land is available in areas zoned for industrial development. Several firms have located here in the last few years, particularly along the Port Chicago Highway across from the main gate of the NWS Concord. Phillips Petroleum Company and Monsanto Chemical Company have facilities along Solano Way near Waterfront Road. There have been no incidents of contamination of Navy lands by these industries.

The City of Concord has a large water treatment plant and reservoir just west of Port Chicago Highway.

Between the Inland and Tidal Areas is a small community known as Clyde, which has a population of 300.

A major oil spill which polluted and damaged the NWS Concord marshlands occurred in 1979 at the Tosco Oil Refinery, located on Suisun Bay on the eastern shore of Pacheco Creek, just west of the station. The incident occurred when a drain valve on a tank was left open. Approximately 2,000 gallons of oil drained into the marsh. Tosco cleaned up the spill to the satisfaction of NWS Concord officials.

## 2.2 Nature and Extent of Problems

Previous studies (Ecology and Environment 1983, Anderson Geotechnical 1984, Lee et al. 1986) have identified seven sites located on eight parcels (571, 572, 573, 574, 575, 576, 579D, and 581) where significant contamination has occurred. These parcels contain approximately 210 acres and include both wetland and upland portions of the tidal plain adjacent to Suisun Bay. The location and general boundaries of each site where hazardous substances have been released are presented in Figure 1.1. The areas requiring remediation are shown on Figures 2.7 through 2.9. A complete description of the nature and extent of contamination at the NWS Concord site is presented in Ecology and Environment (1983), Anderson Geotechnical Consultant (1984), Lee, et al. 1986, and Lee, et al. 1985. A brief history of each site and the activities associated with each are presented below.

2.2.1 Parcel 571 (Canal Pier 4). The United States purchased Parcel 571, on behalf of the Navy, from the Santa Fe Railroad Foundation, Inc., on 7 November 1969. Parcel 571 contains approximately 11.314 acres of land. The Canal Pier 4 site (2.43 acres) is located on Parcel 571. The Pier 4 site is not evaluated in this study but should have remedial actions formulated after additional sampling and chemical analyses have been performed.

2.2.2 Parcel 572 (KS, AA, and AB). The United States acquired Parcel 572, on behalf of the Navy, from Allied Chemical Corporation on 13 November 1969 by declaration of taking. Parcel 572 contains approximately 121.144 acres of land. Three contaminated areas have been found on Parcel 572.

The Kiln Site (KS) encompasses approximately 8.15 acres potentially requiring remediation. Ten large industrial kilns known as Henshoff Ovens or furnaces were operated at this site from approximately 1962-64 until the United States acquired the property on behalf of the Navy. High levels of arsenic, cadmium, zinc, copper, and lead have been detected at this site. The majority of the contamination is believed to be in the upper 6 inches of soil, however, some data indicate contamination to depths as great as 18 inches. A partial clean up of this site was accomplished in 1974.

Allied Site A (AA), encompassing approximately 20.75 acres of tidal marsh, is also located on Parcel 572. High soil concentrations of arsenic, cadmium, copper, and zinc have been detected at this site. Soil pH values as low as 4.6 have also been observed.

Allied Site B (AB) encompassing approximately 8.68 acres of tidal marsh is the final contaminated site on Parcel 572. Site AB is located adjacent to and south of Site AA. High soil concentrations of arsenic, cadmium, copper, and zinc have been detected at this site.

2.2.3 Parcel 573 (K-2). The United States purchased Parcel 573, on behalf of the Navy, from the Santa Fe Railroad Foundation, Inc., on 7 November 1969. Parcel 573 contains approximately 11.533 acres of land. Portions (3.77 acres) of contaminated site K-2 are located on this parcel. High soil concentrations of arsenic, cadmium, copper, lead, and zinc have been detected at this site. A small stream flows through this site before discharging into the tidal marsh.

2.2.4 Parcel 574 (K-2). The United States acquired Parcel 574, on behalf of the Navy, from Elaine A. Nelson on 28 December 1968 by declaration of taking. Parcel 574 contains approximately 11.01 acres of land. Portions (2.79 acres)

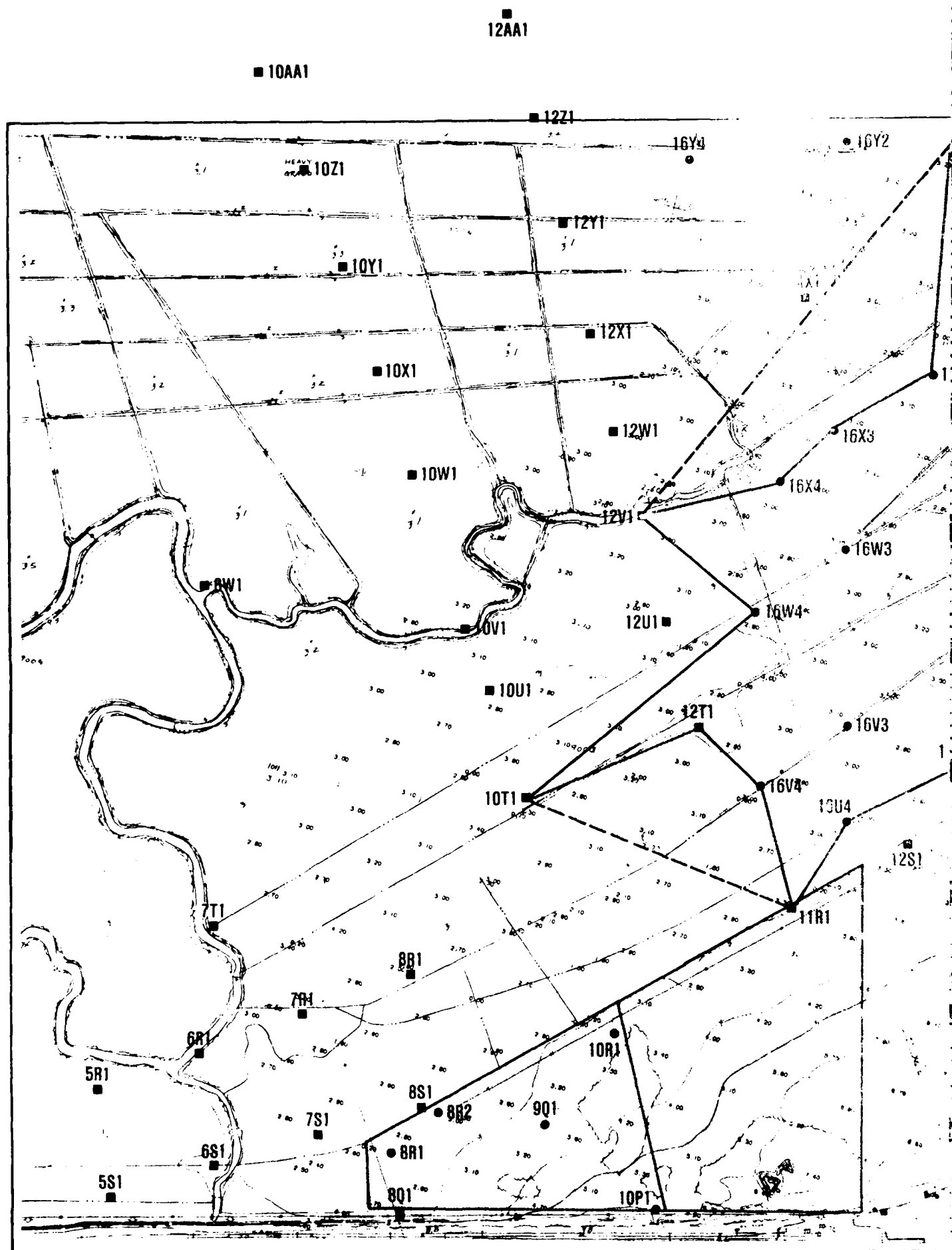
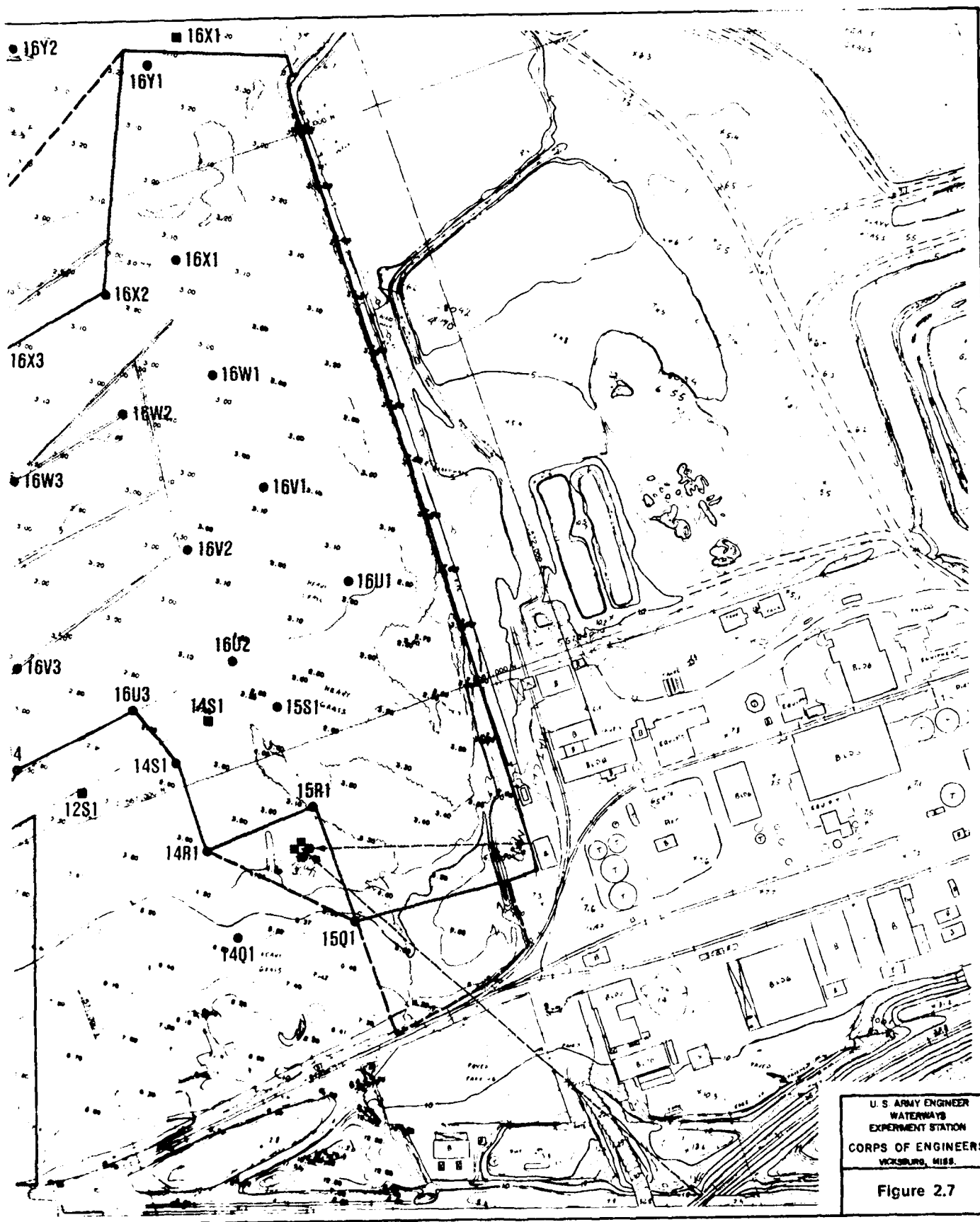


Figure 2.7. Areas of remediation at Sites AA, AB, and KS



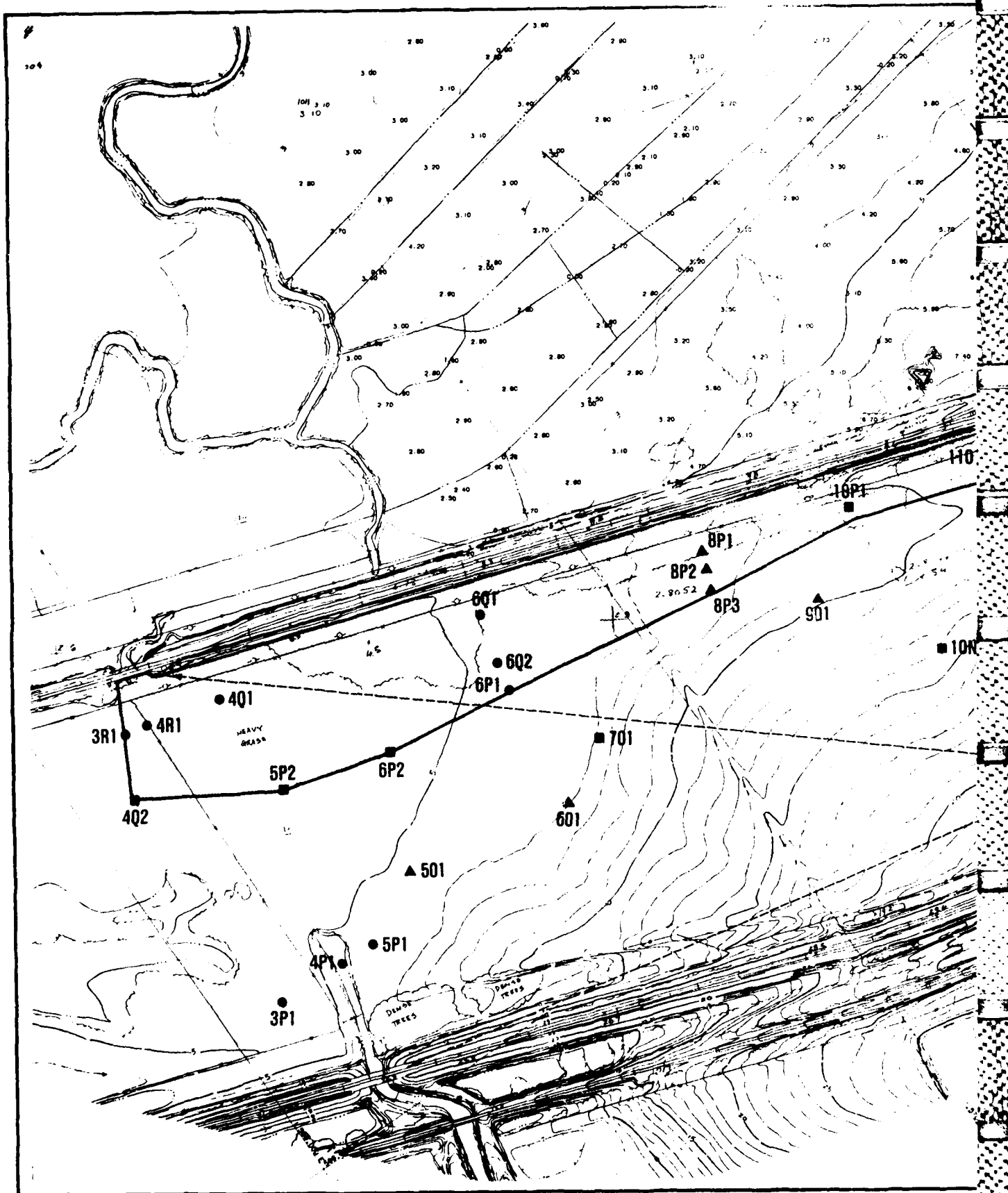
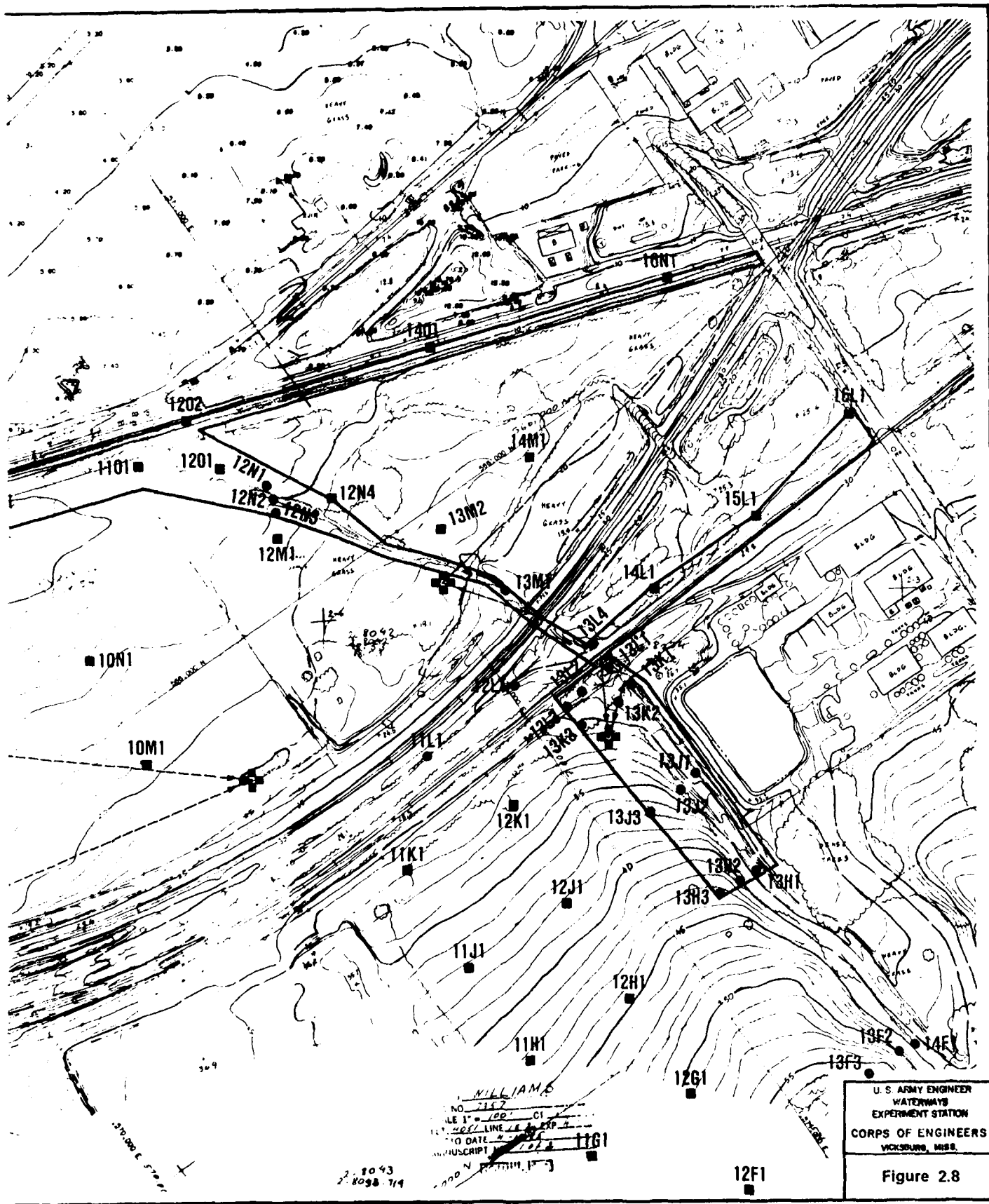


Figure 2.8. Areas of remediation at Sites G1, K2, and ES

102



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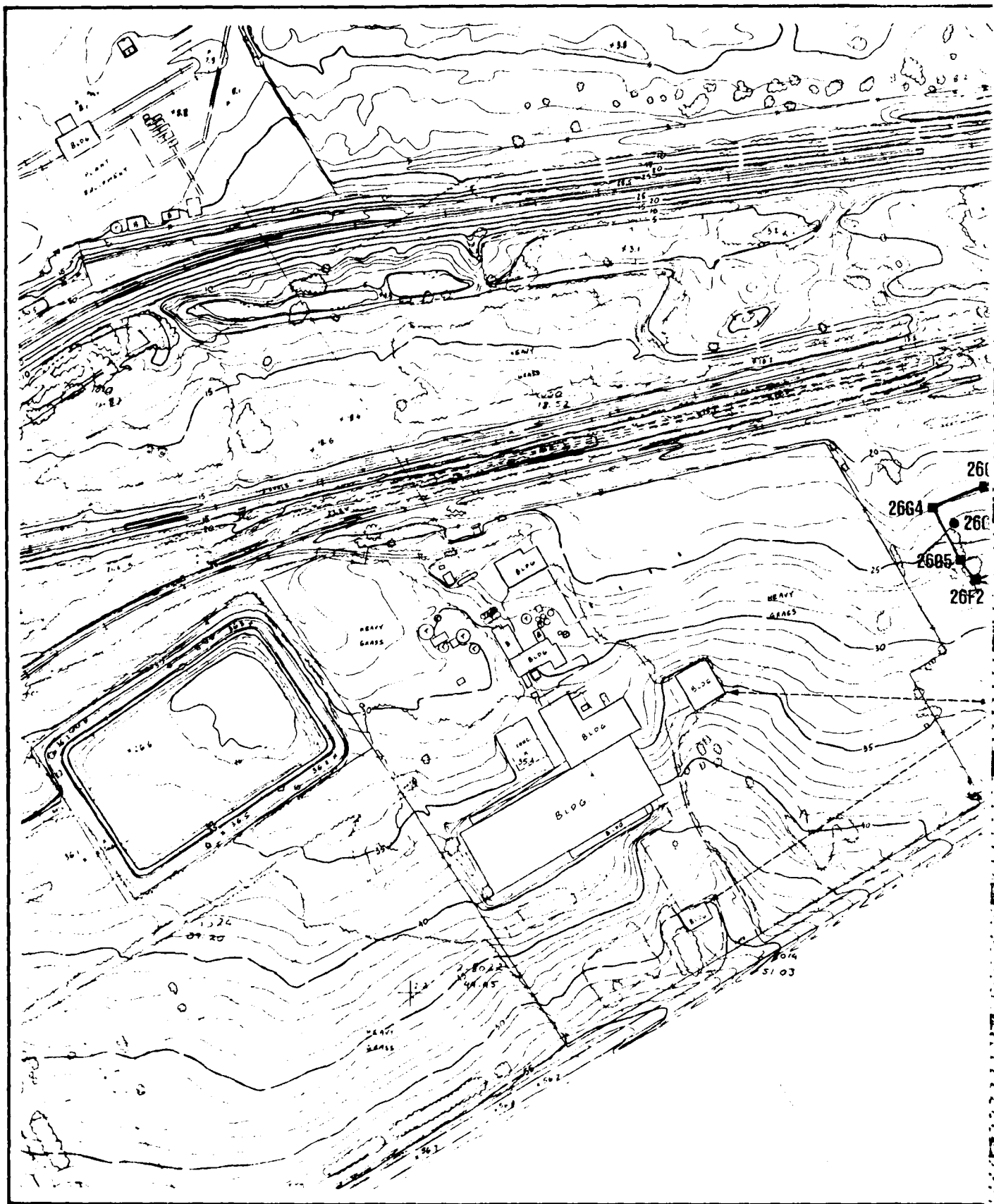


Figure 2.9. Areas of remediation at Site CP

102



U. S. ARMY ENGINEER  
WATERWAYS  
EXPERIMENT STATION  
CORPS OF ENGINEERS  
VICKSBURG, MISS.

Figure 2.9

of contaminated site K-2 are located on Parcel 574. High soil concentrations of arsenic, cadmium, copper, lead, and zinc have been detected at this site.

2.2.5 Parcel 575 (G-1). The United States purchased Parcel 575, on behalf of the Navy, from Getty Oil Company on 26 January 1971. Parcel 575 contains approximately 8.96 acres of land. Contaminated site G-1 (1.60 acres) is located on Parcel 575. This site is adjacent to the Chemical and Pigment Company (ESI) property. A small stream flows through site G-1 before entering site K-2 (Parcels 574 and 573) and finally passing under the Southern Pacific Railroad tracks and emptying into the tidal marsh. Getty Oil Company owned and operated a pumping station known as the Nichols Pump Station on Parcel 575 before the United States purchased the property on behalf of the Navy. High soil concentrations of copper, zinc, cadmium, and arsenic have been found on this site.

2.2.6 Parcel 576 (ES). The United States acquired Parcel 576, on behalf of the Navy, from Marcus H. Gower, Douglas N. Griffin, and Sylvia N. Griffin on 21 June 1971 by declaration of taking. Parcel 576 contains approximately 1.5 acres of land. A portion (0.63 acres) of contaminated site ES is located on Parcel 576. High soil concentrations of lead, copper, zinc, cadmium, and arsenic have been detected at this site.

2.2.7 Parcel 579D (ES). The United States acquired Parcel 579D, on behalf of the Navy, from Fred H. Hewins, Marguerite Tomas, Blurette Basset, Robert Butzberger, Paulette Hembel, Karl Grauwiler, Rudolph Alexander Grauwiler, and Marianne Grauwiler Konig on 24 November 1975 by declaration of taking. Parcel 579D contains approximately 6.35 acres of land. A portion (1.41 acres) of contaminated site ES is located on Parcel 579D. High soil concentrations of lead have been detected at this site.

2.2.8 Parcel 581 (CP). The United States acquired Parcel 581, on behalf of the Navy, from Joe Sobotka and Wilda D. Sobotka on 23 December 1968 by declaration of taking. Parcel 581 contains approximately 10.27 acres of land. Contaminated site CP (3.50 acres), also known as the Coke Pile, is located on Parcel 581. High soil concentrations of arsenic, cadmium, lead, copper, zinc and selenium were found in this area.

### 2.3 Previous Response Actions

By Executive Order 12316, the President delegated authority to respond to the release, or the threat of release, of hazardous substances on Department of Defense property under Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act to the Department of Defense (Federal Register 1981). On 2 November 1981, the Secretary of Defense in turn delegated such authority to respond to release or threatened releases of hazardous substances to the Secretary of the Navy.

The Navy responds to the release or the threat of release of hazardous substances on its property through its Navy Assessment and Control of Installation Pollutants (NACIP) Program. The purpose of the program is to identify, assess, and control the contamination of Navy property by hazardous substances.

Under the NACIP Program, the Navy responds to the release or the threat of release of hazardous substances in a phased approach. In the first phase of the NACIP program, which the Navy calls Initial Assessment, all evidence which indicates that hazardous substances may have been released or may threaten to be released on Navy property must be collected and evaluated. Upon completion of its Initial Assessment Study (Ecology and Environment 1983) of the contaminated sites at NWS Concord in October 1983, the Navy concluded that portions of Parcels 571, 572, 573, 574, 575, 576, 579D, and 581 had been contaminated with hazardous substances including arsenic, lead, copper, cadmium, iron, zinc, and selenium.

During the second phase of the NACIP Program, field studies are conducted to confirm or deny the release or the threat of release of hazardous substances on Navy property and to define the extent of harm or threat of harm to the environment and damage or threat of damage to the natural resources on Navy property. The Navy calls the second phase of the NACIP Program the Confirmation phase. As part of this phase the Navy (1981-1983) had soil and water sampling and analyses conducted on Parcels 571, 572, 573, 574, 575, 576, 579D and 581 to confirm or deny hazardous substance contamination on those parcels (Anderson Geotechnical 1984). The results of those sampling

activities indicated that significant releases of hazardous substances had occurred and demonstrated the need to conduct additional, and more detailed investigations.

Also during the 1981-1982 time frame, the State of California notified the Navy that portions of the eight parcels were contaminated with hazardous substances.

In June 1984, the Navy requested the Army Corps of Engineers, Waterways Experiment Station, to conduct additional studies to confirm or deny the release or threat of release of hazardous substances on Parcels 571, 572, 573, 574, 575, 576, 579D and 581 of NWS Concord, and to define the extent of harm or threat of harm to the environment and the damage or threat of damage to the natural resources on these eight parcels on NWS Concord. The objectives of the study conducted by the Waterways Experiment Station were:

- a. To define the nature and extent of the hazardous substance contamination on the property.
- b. To assess the bioavailability, mobility, and toxicity of the hazardous substances to plant and animals species on the property.
- c. To identify the sources of the hazardous substances detected on the property.
- d. To evaluate the extent of the migration of the hazardous substances on the property.
- e. To evaluate the condition of the wetland and upland habitats on the property.

The WES studies (Lee et al. 1986, Lee et al. 1985) identified areas of significant contamination and recommended that implementation of remedial actions were appropriate for one or more of the contaminated sites. This feasibility study is the result of that recommendation.

#### 2.4 Statutes, Regulations, and Authorities

Federal statutes, regulations, and other authorities with which the Navy may have to comply in responding to the release or the threat of the release of hazardous substances on Parcels 571, 572, 573, 574, 575, 576, 579D, and 581 of NWS Concord include:

- a. The Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et seq.
- b. The Resource Conservation and Recovery Act, 42 U.S.C. 9601 et. seq.
- c. The Federal Water Pollution Control Act, 33 U.S.C. 1251 et. seq.
- d. The River and Harbor Act, 33 U.S.C. 401 et. seq.
- e. The Endangered Species Act, 16 U.S.C. 1531 et. seq.
- f. The Migratory Bird Conservation Act, 16 U.S.C. 703 et. seq.
- g. The Safe Drinking Water Act, 42 USC 300 f et. seq.
- h. The National Oil and Hazardous Substances Contingency Plan, 40 C.F.R. Part 300.
  - i. Solid Waste, 40 C.F.R Subchapter I.
  - j. Designation of Hazardous Substances, 40 C.F.R. Part 116.
  - k. Determination of Reportable Quantities for Hazardous Substances, 40 C.F.R. Part 117.
  - l. Regulatory Programs of the Corps of Engineers, 33 C.F.R. Parts 320-330.
  - m. Section 404 (b) (1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 40 C.F.R. Part 230.
  - n. Endangered and Threatened Wildlife and Plants, 50 C.F.R. Part 17.
  - o. Response to Environmental Damage, Executive Order 12316, 46 Fed. Reg. 42237 (14 August 1981).
  - p. Protection of Wetlands, Executive Order 11990, 42 Fed. Reg. 26961 (25 May 1977).
  - q. Memorandum of Understanding Between the Department of Defense and the Environmental Protection Agency for the Implementation of P.L. 96-510, The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (12 August 1983).
  - r. Memorandum of Understanding Between the Department of the Navy and The U. S. Fish and Wildlife Service Relating to Designation of Wetland Preserve on the Naval Weapons Station, Concord, California.

s. Region IV Oil and Hazardous Substance Pollution Contingency Plan.

t. Memorandum from Secretary of Defense (2 November 1981).

u. Navy Assessment and Control of Installation Pollutants Program.

State statutes and regulations which may provide guidance to the Navy in responding to the release or in the threat of the release of the hazardous substances on Parcels 571, 572, 573, 574, 575, 576, 579D, and 581 include:

v. The California Solid Waste Management, Resource Recovery and Recycling Act of 1972, California Government Code, Title 7.3, Chapter 1, Section 66700, et. seq.

w. The California Hazardous Waste Control Act, California Health and Safety Code, Division 20, Chapter 6.5, Section 25100, et. seq.

x. The California Underground Storage of Hazardous Substances Act, California Health and Safety Code, Chapter 6.7, Section 25280 et. seq.

y. The California Porter - Cologne Water Quality Act, California Water Code, Division 7, Section 13000 et. seq.

z. The California Coastal Act, California Public Resources Code, Division 20, Section 30000 et. seq.

aa. Migratory Birds, Article 3, Sections 355-357, Fish and Game Commission, California Fish and Game Code, Division 1, Section 101 et. seq.

bb. Keene-Nejedly California Wetlands Preservation Act, California Public Resources Code, Chapter 7, Section 5810 et. seq.

cc. San Francisco Bay Conservation and Development Commission, California Government Code, Title 7.2, Section 66600, et. seq.

dd. Suisun Marsh Preservation Act of 1977, Public Resources Code, Division 18, Chapter 3, Section 29200 et. seq.

ee. Endangered Species, Chapter 1.5, Section 2050 et. seq., California Fish and Game Commission, California Fish and Game Code, Div. 3, Section 2000 et. seq.

ff. California Hazardous Waste Management Regulations, California Administrative Code 1 - Title 22, Social Security, Division 4, Environmental Health, Chapter 30 Minimum Standards for Management of Hazardous, and Extremely Hazardous Wastes.

gg. California Water Regulations, California Administrative Code, Title 23, Waters, Chapter 3 - State Water Resources Control Board, Sections 1050 through 2836.

### 3.0 CONTAMINATION ASSESSMENT

A comprehensive assessment of environmental damage is documented in Lee, et al. (1985b). Additional information on the areas of contamination is provided in Lee, et al. (1986). The following brief discussion is extracted from these reports.

#### 3.1 Potential Contaminant Migration Pathways

A generalized scheme of the potential pathways for contaminant mobility at NWS Concord is illustrated in (Figure 3.1). The major source of contamination at the NWS Concord is hazardous substances that have been deposited and/or mixed with surface soils at seven sites. These hazardous substances are primarily cadmium, lead, copper, selenium, zinc and arsenic. Potential migration pathways for these contaminants include: air, surface water, and ground water. In addition, there is some potential for direct contact, human, animal, or plant with contaminants on the various sites. Lee et al. (1986, 1985) evaluated the potential for contaminant migration by each of these pathways. The major findings of these evaluations are presented below.

3.1.1 Air Pathway. The high energy wind environment on the NWS Concord results in the potential transport of contaminated soils and dry sediments by wind action. Numerous barren areas located in the study area are highly susceptible to this surface wind activity and movement of contaminants via volatilization or fugitive dust is likely. Although no quantitative measurement of the problem has been made, qualitative observations indicate that fugitive dust is generated and carried off the individually contaminated sites. There is potential for affecting human, plant, and animal life on uncontaminated areas of NWS Concord as well as biological ecosystems miles from the contaminated sites. Personnel working at NWS Concord and for the private companies adjacent to the study area are potentially exposed daily to the risk of contamination from airborne soil particles.

Table 3.1 shows the percentage frequency of wind direction and speed at the Pittsburgh power plant, on the shore line a few miles east of the site. Velocity measurements were taken 33 ft above the ground, and wind speed at the



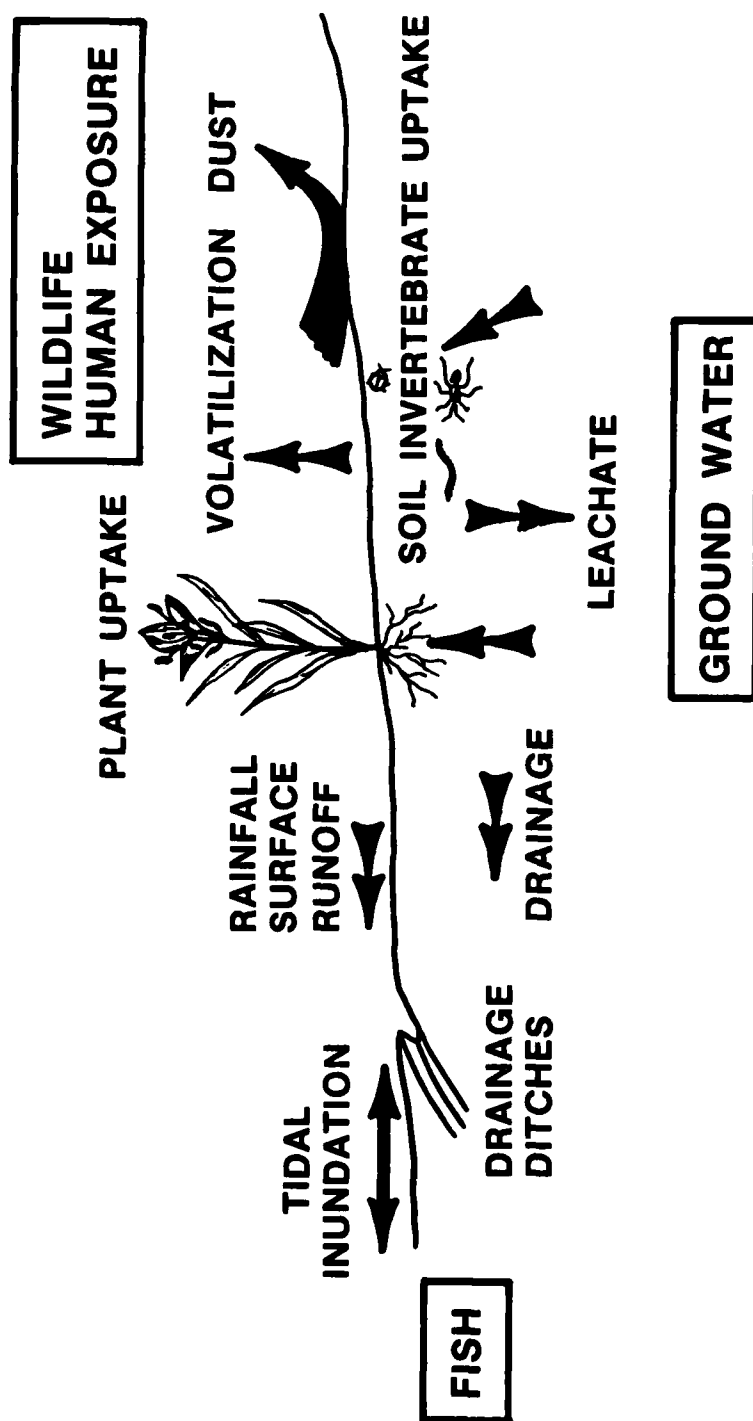


Figure 3.1. Pathways for contaminant mobility.

Table 3.1  
 Percentage Frequency of Wind Direction and Speed at Pittsburg Power Plant  
 (from California DWR, 1978)

# **SURFACE WINDS**

## **PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED (FROM HOURLY OBSERVATIONS)**

STATION Pittsburg Power Plant, CA DATE December 1970 thru November 1973 ALL  
 CLASS ALL WEATHER ALL  
 LOCATION 38°03' 121°54' 20' (LONG (LAT))  
 HEIGHT ABOVE GROUND 33 feet

SPEED MPH DIR.	1-3	4-7	8-12	13-18	19-24	25-33	34-44	%	MEAN WIND SPEED
N	0.8	0.7	0.5	0.6	0.3	0.2	0.0	3.1	10.1
NNE	0.5	0.4	0.2	0.1	0.0	0.0		1.2	6.0
NE	0.7	0.7	0.1	0.0	0.0			1.6	4.8
NNE	0.7	1.3	0.3	0.0	0.0			2.4	4.8
E	1.5	2.7	0.9	0.2	0.0	0.0		5.3	5.5
ESE	1.3	1.7	1.0	0.3	0.1	0.0		4.5	6.5
SE	1.4	0.8	0.4	0.2	0.0			2.8	5.2
SSE	0.9	0.4	0.1	0.1	0.0			1.6	4.1
S	1.2	0.4	0.3	0.1	0.1	0.0		2.0	5.1
SSW	1.0	0.6	0.7	0.5	0.2	0.0	0.0	3.0	7.9
SW	1.1	1.8	3.9	4.4	0.7	0.1	0.0	11.9	11.3
WSW	0.9	2.6	7.4	8.2	1.9	0.0		21.1	12.2
W	1.0	3.0	7.6	8.9	1.8	0.0		22.3	12.1
WNW	0.7	1.8	3.3	3.8	0.4	0.0		10.0	11.0
WW	0.7	1.2	0.9	0.8	0.1	0.0		3.8	8.5
WNW	0.7	0.5	0.3	0.4	0.4	0.1		2.4	10.1
CAUA								0.2	10.1
0.9	15.2	20.6	28.0	28.6	6.1	0.5	0.0	99.9	

DATA FROM Pacific Gas and Electric Company  
 TOTAL NUMBER OF OBSERVATIONS 23,568

soil surface would be less. The numbers indicate that 30.2 percent of the time, the wind blows from the southeast to west northwest at 13 mph or more, and that wind speeds exceeding 25 mph occur 0.5 percent of the time, or about 44 hours per year.

This process is limited by the presence of sheltering vegetation, the cohesion of the sediment, and wetting due to high water table. Frequent tidal inundation will tend to stabilize particles, consequently the drier, higher elevation areas such as the kiln site (KS) on Parcel 572 will be more susceptible to wind erosion.

3.1.2 Surface Water Pathway. Analysis of water samples as well as the known physical chemistry of heavy metals indicates that the copper, zinc, lead and cadmium on NWS Concord are most likely adsorbed on sediments or precipitated in relatively insoluble compounds (Huang, et al., 1977). Though held in solid form, the contaminants may still be transported by surface water. Even relatively low water velocities could effectively move contaminated fine textured sediment. Contaminated sediment is moved by several different surface water mechanisms individually or in combination. These are discussed below.

3.1.2.1 Interaction of Nichols Creek and the Kiln Site. Any contamination picked up by Nichols Creek as it runs past the Chemical and Pigment Company would be transported to the kiln site if the flow could reach the old Southern Pacific culverts. There are three ways that this might occur.

First, the water depth in Nichols Creek, as it flows west past the location of the old route through the culvert, could rise to a surface elevation that would overtop the berm protecting the culvert. Any such overtopping of the berm in this area would flow directly to the culvert.

Second, if the right bank of the Creek (looking downstream) overflowed at a location about 400 to 500 ft or more upstream of the area near the culvert, the water would flow straight north to a depression, and from there would flow into the ditch which runs along the south side of the tracks and then westward to the culvert.

Third, if water were backed up by the single culvert under the unpaved road just north of the AT & SF tracks, when the water began to overflow the road the water from the right bank would flow north to the same depression noted in the second possibility above, and from there into the ditch to the culvert.

To study the peak discharge conditions which might lead to the first two possibilities outlined above, the water surface profiles of the creek under various discharge conditions were modeled. This was accomplished with HEC-2, a program developed by the Hydrologic Engineering Center of the US Army Corps of Engineers. Nine cross sections of the creek and overbank areas were used as input, along with peak flows for Nichols Creek and the tributary stream (Figure 3.2).

It was decided to begin by ignoring the possibility that the various culverts upstream (at the unpaved road and at the railroad tracks) might restrict the peak flows during a storm event, and to assume that the calculated peak discharge for the recurrence interval was flowing in the creek channel at the locations of interest. Peak discharges calculated by both the rational method and by the method of Waananen and Crippen (1977) were considered (Table 2.2).

If the calculated water surface elevation at section 8 rose above 10.0 ft, then overflow of the berm directly into the culvert (as outlined in possibility number one above) would occur. If the calculated water surface elevation at section 9 rose above 13.5 ft, then overflow of the right bank with flow to the cave-in and ditch would occur (as outlined in possibility number two above).

Discharges of 219 and 340 cfs were used. These correspond to recurrence intervals of about 3 years and 10 years by the rational formula, and 10 years and 25 years by the Waananen and Crippen method. A discharge of 219 cfs did not produce overflow to the culvert by either of the possibilities above. A discharge of 340 cfs, however did produce overflow to the culvert by overflowing the banks of the stream at section 9, that is, by overflowing as outlined in possibility number two above.

Finally, the third possibility outlined above was briefly considered. Here, the culvert pipe under the unpaved road (a single 18" diameter corrugated metal pipe) could cause the water to back up behind the culvert until it began to overflow the road. If this happened, a significant part of the flow would continue downhill over G-1 area and into the right overbank area to the cave-in depression and the ditch, rather than returning to the stream channel.

It appears that the culvert in the G-1 area is completely inadequate, and that it is not able to pass the peak discharge of even a two year event (Portland Cement Association, 1969). The culvert pipe appears to be fairly new, and it is not known how long this culvert configuration has been in position. However, it appears that overflow into the right overbank area must occur fairly frequently.

3.1.2.2 Bank and surface erosion during flood flows on Nichols Creek. The HEC-2 results for discharges of 219 and 340 cfs suggest some inferences about potential erosion or deposition of sediment. Table 3.2 shows the calculated average velocities at the upper two cross sections that were used in the model. At section 8, Nichols Creek would spill into the old culverts; at section 9 (upstream from 8), it would flow into the cave-in and then into the ditch next to the SP tracks. The results at section 9 show that at the higher discharge, velocity in the channel is lower. This is because (in the model, at least) the flow is spread over a larger area. Maximum velocity along the bank at the outside of the channel bend would be greater than the average.

A simple calculation using the shield equation (Henderson, 1966) indicates that at a flow of 219 cfs, the stream could theoretically entrain sediment particles as large as 0.6 inches diameter at section 8, and even larger particles at section 9. The actual erosion rate would depend on the degree of consolidation and density of vegetation.

Before the old culvert was diverted (probably in the 1960's) suspended solid material was deposited west of the kiln site below the Southern Pacific tracks. The results of computed water surface profiles indicated that flood flows from a 25 year storm would carry suspended solids over the creek bank through the culvert onto Parcel 572 at the kiln site. Any contamination from

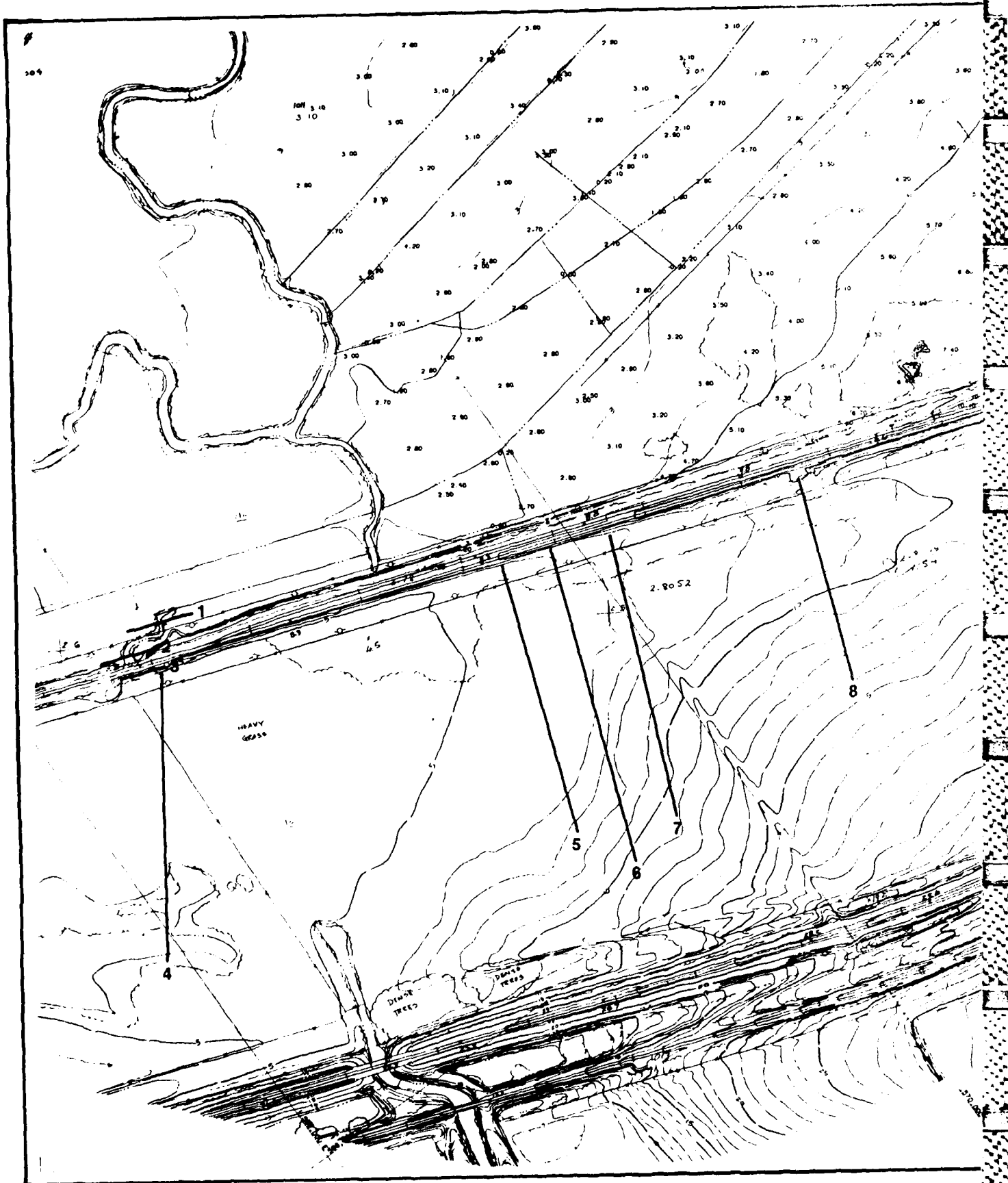


Figure 3.2. Cross sections for HEC-2 analysis

16.2

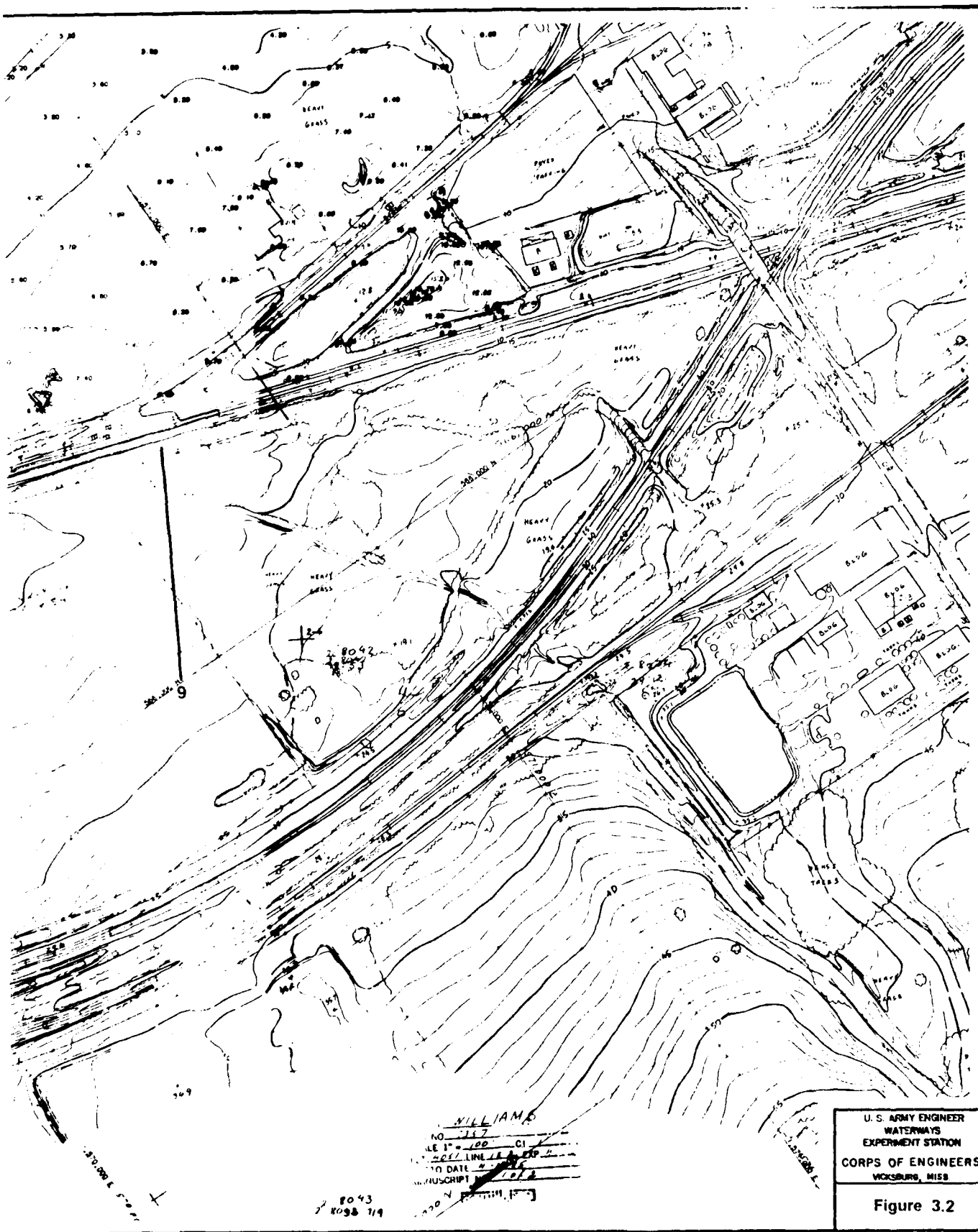


Table 3.2  
Velocity (ft/sec) in Nichols Creek above Southern  
Pacific Railroad tracks, based on HEC-2 results.

Sec. No.	219 cfs			340 cfs		
	Left overbank	channel	Rt overbank	Left overbank	channel	Rt overbank
8	.84	1.47	.90	1.01	1.64	1.10
9	---	3.54	---	.01	1.87	1.68

ES (Parcel 579D), Parcel 576 and G-1 (Parcel 575) would be released onto Parcel 572.

Velocities in Nichols Creek adjacent to the Chemical Pigment Company (above the railroad tracks) were not calculated. Since the channel is narrower and steeper, velocity at this location should be greater than below the tracks. The culverts under the tracks might pond the stream temporarily. The magnitude of this effect would depend largely on the amount of sediment deposited in the culverts, which for historic conditions is not ascertainable.

3.1.2.3 Tidal Scouring. Once contaminated sediments have been deposited in the marsh, they are remobilized by tidal action. Sediments deposited in slough channels where velocities are higher can scour fairly rapidly and redistribute into the tidal drainage system, eventually moving out to Suisun Bay. Sediments and contaminants deposited on the marsh plain tend to be less mobile because of lower velocities and lower frequency of inundation. The tidal frequency analysis indicates that a tide that would be expected on the average 1.3 times per year is capable of distributing fine sediment over much of the marsh plain.

The actual rate of spread of contaminants by tidal action depends on the interaction of several variables that are difficult to quantify. These include the particle size and density of contaminated sediment, the density of vegetation growing on contaminated areas of the marsh, and the magnitude and frequency of wind-generated waves during high tides. Regardless of the complexity of the mechanisms and variables involved, however, the distribution of



heavy metal contaminants in the marsh (Lee et al. 1986) corresponds to a large extent with the tidal drainage network.

3.1.2.4 Wave Action - Erosion of the Marsh Plain. Large amounts of contaminated sediment are mobilized by wave action during extreme tides. Extreme tides are caused by the superimposition of storm surges on normal high tides. These occur during the winter months and can be accompanied by local storm conditions. For example a 10-year high tide will flood the marsh plain to depths of about 2-1/2 ft. With the long fetch of Suisun Bay to the west, considerable wave action is generated that erodes surface sediments and redistributes such sediments on the marsh and into Suisun Bay. The erosion is limited by the presence of vegetation and the degree of cohesion of the sediment.

3.1.2.5 Wave Action - Erosion of the Bayward Margin Intense wave action, even at normal high tides, cause erosion of the bayward margin of the marsh plain. In the past, the edge of the marsh has experienced both erosion and accretion. However, in the future it is more likely to undergo additional erosion than accretion. This is due to the reduction of sediment supply to Suisun Bay over the last 50 years caused by dam construction, the dissipation of the "wav " of sediment carried into the system due to hydraulic mining in the nineteenth century, and the sea level rise. Sea level rise is now predicted to accelerate due to global climatic changes (EPA 1983). This would cause substantial erosion of the shoreline, distributing deposited sediments into Suisun Bay.

3.1.3 Ground Water Pathway. There is a well on the Chemical and Pigment Company land, located between the holding pond and the Sacramento Northern Right-of-Way. This well is not listed in the California Department of Water Resources Water Data Information System. In a study for the Chemical and Pigment Company, Kleinfelder and Associates (1983) installed and sampled three monitoring wells for zinc and copper. All samples were within drinking water standards for the two metals. Data are not available however, for lead, arsenic, cadmium or selenium for the monitoring wells or the supply well. Water samples from this well should be analyzed for the latter elements as

well as the former. Kleinfelder (1983) found that the direction of water movement is toward the northeast.

Brown and Caldwell (1985) installed soil water extractors (lysimeters) at five locations in the contaminated area in 1985. Samples of soil water were collected from two depths (12 and 24 inches) and analyzed for arsenic, selenium and heavy metals. The results suggested limited contamination of soil water at two locations. In the KS site of Parcel 572, a sample from 24 inches exceeded EPA criteria (1976) for drinking water by a factor of 80 for cadmium and by a factor of 28 for zinc; in the AA area of Parcel 572, the criteria were exceeded for arsenic by a factor of 3, at 12 inches depth. Unfortunately, the collection of water by the soil water extractors was not very successful, and only a few samples were analyzed.

The potential for groundwater contamination depends not only on the degree to which the metals are adsorbed or precipitated, but also on the permeability of the soil overlying the water table. A study by Harding-Lawson Associates (1977) found that although the peat of the undisturbed marsh is fairly permeable, the marsh soils are underlain 15 to 20 feet below the surface by a relatively impermeable layer of stiff sandy silt. The presence of this relatively impermeable layer makes contamination of the groundwater unlikely. Lateral movement of contaminants within the surface permeable peat is possible; however, peat has an exceptional adsorptive capacity for metals and would restrict migration laterally. In addition, metals are likely to be precipitated as sulfides and carbonates further restricting their movement through the marsh soil.

Selenium, which is still present in the CP site on Parcel 581, is more mobile than most metal ions. While groundwater samples have not been analyzed for selenium, the CP site seems to represent a relatively small and localized potential source.

3.1.4 Biological Uptake and Accumulation. A fourth major pathway of contaminant mobility is related to biological uptake and accumulation. Potential release of contaminants can occur through plant uptake and may result in an accumulation of contaminants at levels exceeding normal tissue contents.

Animals feeding upon contaminated plants are at higher risk of becoming contaminated than animals feeding on uncontaminated plants in the same locale. Potential release of contaminants can occur through uptake by soil-dwelling animals. Wildlife whose diets consist of soil invertebrates may ingest contaminated organisms, accumulating contaminants to levels that result in adverse physiological effects on these animals.

Contaminant mobility into aquatic ecosystems commences with rainfall initiated surface runoff or movement of detritus and soluble contaminants into drainage ditches and subsequently into Suisun Bay through the actions of tidal inundation. Surface drainage also introduces soluble contaminants into the aquatic ecosystem of the bay. Fish are potentially exposed to any influx of contamination into the aquatic environment by feeding upon flora and fauna that may have accumulated contaminants introduced into the bay.

Ground-water contamination can potentially occur from soil moisture leaching through the soil profile into the ground-water aquifer. Contaminants must be in a soluble and mobile form to leach through the soil profile. The interactive effects of plant uptake, soil invertebrate absorption, and adsorption to soil particles and organic matter provides a rather efficient biological filter to clean leachate as it penetrates the soil profile. However, as plants and soil invertebrates die and decompose, contaminants are released and can be susceptible to leaching into the ground-water.

3.1.5 Direct Exposure. There is potential for direct contact to on site contaminated materials. Potential receptors include personnel working at the site during remedial activities, general site trespassers, and personnel employed at adjacent industrial and agricultural activities. The potential for direct contact is reduced somewhat by the isolated locations of several of the sites and land use controls implemented by the Navy.

3.1.6 Summary. The movement of contaminants through air, soil, water, and biota involves complex chemical and biological interactions. Consequently, biological testing is necessary to assess the potential for contamination to move from the soil into the biota of the ecosystem. Certain bioassay procedures have been developed to indicate and quantify the potential for

contaminant mobility into food chains. The primary point of emphasis is: mobile contaminants not only exert their greatest influence and cause the most biological damage on site, but also at some distance from the source.

On site contamination within each area has been documented in the RI (Lee et al. 1986). In addition, migration of contaminants from each area is occurring. The primary exposure pathways appear to be surface water and biological uptake and accumulation. Secondary pathways appear to be the air and direct contact. The groundwater pathway appears to be of minor importance.

### 3.2 Damage and Endangerment Scenarios

Existing and potential damage, human health and environmental concerns, and endangerment scenarios are described in Lee, et al. (1986, 1985).

### 3.3 Environmental Protection Goal

An evaluation of the contaminant types and concentrations found at the seven contaminated areas at NWS Concord indicates that the primary contaminants of concern are heavy metals, including lead, cadmium, copper, and zinc as well as arsenic and selenium. Based on a variety of existing standards (Lee et al. 1986, 1985), the contamination has significantly degraded surface soils and is a present or potential threat to human, wildlife, and vegetative populations using the sites or areas adjacent to the contamination.

The environmental protection goal is to minimize or eliminate the continued release and potential release of hazardous substances into the environment from the various contaminated sites. This is to be accomplished using cost effective remedial action alternatives that do not, in themselves pose a significant long term adverse impact to important wildlife habitat.

#### 4.0 EVALUATION OF THE NO ACTION ALTERNATIVE

The preceding summary assessment of contamination and endangerment at the NWS Concord site and the detailed Remedial Investigation damage assessment (Lee, et al. 1986 and Lee et al. 1985) identified contamination of the surface soils as the principal concern. These studies evaluated known site conditions using a variety of criteria.

The goal required by the Comprehensive Environmental Response, Compensation and Liability Act is protection of human health, welfare and the environment. The principal impact to the environment is the contamination of wildlife habitats in the vicinity of the site and continued migration of hazardous substances into the environment surrounding the contaminated areas at NWS Concord. Surface soil contamination is of primary concern because of the potential endangerment to the following categories of receptors:

- a. Existing and future human users of the contaminated areas through direct contact;
- b. Existing and future wildlife users coming into direct contact with the contaminated areas;
- c. Vegetation coming into direct contact with contaminated areas;
- d. Wildlife exposed to hazardous substances via food chain contamination; and
- e. Human, wildlife, and vegetation exposed to contamination resulting from the continued migration of contaminants into the environment.

Secondary areas of concern include:

- a. Exposure of humans in the immediate vicinity of the contaminated areas; and

b. Release of hazardous substances via a catastrophic event such as an earthquake or flood.

An environmental goal was established which calls for abating the release of hazardous substances, using cost effective measures, without adversely impacting important wildlife habitat in the long term. Therefore, the adequacy of the no-action alternative should be assessed in terms of its ability to meet this environmental protection goal.

Under the no action alternative, site conditions would not be changed. Existing contaminated areas would be left in their current state. Direct access to the site, however, would be limited by posting of contaminated areas.

Large quantities of hazardous substances (primarily heavy metals) were deposited at various areas on the NWS Concord. The Remedial Investigation (Lee et al. 1986) and previous studies (Ecology and Environment 1983; Anderson Geotechnical 1984) have documented the migration of these hazardous substances. Contaminants have been found to exceed various criteria (Lee, et al. 1985) and remote uncontaminated reference levels (Lee, et al. 1986) in surface soils. It is reasonable to conclude that these contaminated areas and the resultant migration of hazardous substances result from the improper handling of hazardous substances.

On site sampling and subsequent analysis have confirmed that significant quantities of hazardous substances remain at the various contaminated areas. These substances are subjected to environmental stresses from the horizontal flow of surface water over and through the hazardous substances and, to a lesser extent, vertical infiltration of water through the waste and into the ground water and wind generated fugitive dust. It is anticipated that migration of contaminants from the site through the surface water media will continue in both the near and long term.

The no action alternative does not provide the necessary reduction in endangerment or continued environmental damage required by the environmental protection goal.

## 5.0 REMEDIAL ACTION OBJECTIVES AND GOALS

Evaluation of the no-action alternative has indicated that it will not be capable of meeting the environmental protection goal with an acceptable level of risk. Therefore, some form of remedial action is deemed necessary for the NWS Concord Site. Evaluation of the many possible remedial actions requires formulation of remedial action goals and objectives. The environmental protection goal developed in Chapter 3 is a primary goal. In addition to the primary goal, there are a number of other goals that must be considered. Generally, these secondary goals or criteria address the relative desirability of the specific remedial alternatives.

Development of specific evaluation criteria is preceded by identification of specific goals related to the remedial action. Criteria are then developed to provide a means of assessing if these goals are being met. This assessment can be made less subjective if the criteria can be expressed in quantitative terms. The goals and criteria developed for remedial actions at the NWS Concord Site address the general topics listed below:

- Reliability;
- Implementability;
- Technical Effectiveness/Efficiency;
- Environmental Concerns;
- Safety Requirements;
- Operation and Maintenance Requirements;
- Costs;
- Regulatory Requirements; and
- Public Acceptance.

### 5.1 Reliability

Reliability criteria address the performance of a remedial action and the uncertainty associated with performance. In general, efforts are made to select methods having maximum reliability. As a practical consideration, however, acceptable reliability is often measured against the consequences of

failure. That is, the greater the consequences of failure, the greater the required reliability.

A general remedial action goal should be selection of a reliable remedial alternative. This may appear to be a trivial requirement since, in theory, all candidate methods should be reliable. That is, a method would never be designed to be unreliable. The difficulty, however, lies in assessing the uncertainty associated with the specified reliability. This uncertainty can be minimized through the use of methods which have already been proven by application under similar conditions.

A second remedial action goal should be to minimize the consequences of failure of the remedial action. A general guideline for acceptable consequences of failure should be comparison with the no-action alternative. That is, at a minimum, failure of an alternative should not present consequences worse than implementation of no remedial action.

In consideration of the above, the following reliability criteria were applied:

- The method must have been proven effective in similar applications.
- Failure of the method at any time prior to the design life should not result in contaminant concentrations greater than those expected for the no-action alternative.

## 5.2 Implementability

Implementability criteria should address site-specific conditions which may impact implementation of the remedial action. Typically, implementability concerns result from requirements for materials or conditions which may not be present at the site. Remedial alternatives should generally be chosen which do not require materials or conditions not readily available at the site. If required materials or conditions are not present it may still be technically possible to implement an alternative. The cost of implementation may, however, be prohibitive.



A general goal should be to select methods which are not significantly impacted by site conditions. The impact of site conditions on implementability is best quantified by the effect on cost. This goal is reflected in the following criterion:

- The unit cost of implementation of a technology at the NWSC Concord Sites should not be greater than the maximum reported unit cost of implementation at other sites (adjusted for changes in cost levels).

### 5.3 Technical Effectiveness/Efficiency

Technical effectiveness/efficiency criteria should address the ability of an alternative to meet remedial action goals. It is assumed that all alternatives under consideration will be able to meet the environmental protection goal developed in Section 3.3. Consideration of technical effectiveness should, therefore, address the uncertainty involved in meeting this goal.

A general goal should be to select methods which are effective in meeting the environmental protection goal with a high degree of certainty. The ability of an alternative to meet this goal should be assessed by comparison of required performance with typical or expected performance. Assessment of effectiveness is expressed by the following criterion:

- The required technical performance of a remedial action should be within the typical range of operating performance for that alternative.

### 5.4 Environmental Concerns

Evaluation of environmental concerns should also address secondary impacts. Secondary environmental concerns include such things as loss of habitat, noise, and airborne releases from implementation of remedial alternatives. Identification and quantification of secondary impacts is highly case-specific. In general, however, a goal of remedial actions should be to minimize such impacts. The reference for assessing secondary impacts should

be the no-action alternative. To be effective in minimizing secondary impacts, a remedial action should meet the following criterion:

- A remedial action should not result in any long term impacts to the environment greater than those that would occur with the no-action alternative.

#### 5.5 Safety Requirements

Safety requirements criteria should address the safety of both on-site personnel and the general public. On site safety requirements should consider the hazards posed by implementation of remedial actions. The impacts of these requirements on alternative evaluation is often assessed by their economic impact. That is, it should be technically feasible to assure safety under almost any condition, though the cost of doing so may be prohibitive. Public safety requirements should consider the access the public will have to the site after remedial actions have been implemented.

A goal of remedial actions should be to minimize safety hazards to both on-site personnel and the public. This goal should be met with the minimum possible impact on the cost of a remedial action. To attain this goal, the following criteria should be met:

- The near term safety hazards posed by a remedial action to site personnel and the public should not be greater than the combined short and long term safety and health hazards posed by the no action alternative.
- The cost of assuring worker and public safety should not result in a significant increase in costs beyond those required to meet the environmental protection goal.

#### 5.6 Operation and Maintenance Requirements

Operation and maintenance (O&M) requirements criteria should address the material and resource requirements necessary to operate and maintain the remedial action. The impact of O&M requirements is typically expressed as an

economic cost. While it is generally desirable to minimize these costs, the effect of O&M cost reductions must be assessed in terms of the overall cost of the alternative. That is, reductions in O&M costs are frequently offset by increases in capital costs. Evaluation of methods having similar total overall costs must consider the preferability of capital costs (i.e., present costs) to O&M costs (i.e., future costs). The relative preference of costs should be based on the certainty of cost data and the source of funding. In general, there is more certainty with capital (present) costs than with O&M (future) costs. If funding for implementation of remedial actions is to come from cost recovery litigation, it may be preferable to select capital intensive alternatives having low O&M costs.

Therefore, a goal of remedial action evaluation should be to select alternatives which minimize O&M costs and requirements consistent with minimum overall costs. It is difficult to express a quantitative criterion for this goal because of the effects of site specific conditions and uncertainties over costs. The following criterion is provided for general guidance in evaluating alternatives.

- Among remedial alternatives having approximately equal total cost and effectiveness, the alternative having the minimum O&M cost should be selected.

#### 5.7 Cost

Cost criteria should address the overall cost of implementing a remedial action. In general, it is desirable to select the remedial action with the lowest overall cost. There are difficulties in basing decisions solely on costs since other important factors may be overlooked. Therefore, selections should be based on cost effectiveness, which considers costs along with technical performance factors. Cost effectiveness should be based on an evaluation of present worth costs.

A goal of remedial action selection should, therefore, be to minimize costs while meeting all other goals. This goal is expressed in the following criterion:

- The most cost effective alternative that meets the environmental protection goal should be selected for implementation. The cost effective alternative is the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare or the environment (National Contingency Plan, 1984).

#### 5.8 Regulatory Requirements

Regulatory requirements criteria should address compliance with applicable regulations and the impact of compliance on the feasibility of remedial alternatives. Regulatory requirements are important since they can determine the acceptability of a remedial action as well as impact the cost of implementation. Since it is assumed that all remedial actions must comply with all appropriate regulations, it may be argued that these requirements would impact all remedial actions equally. However, not all regulations will apply equally, if at all, to all remedial alternatives. For example, only those remedial alternatives resulting in discharges to surface waters would have to comply with the NPDES requirements of the Clean Water Act.

While remedial alternatives are not required to comply with the Resource Conservation and Recovery Act (RCRA), it is desirable that at least one alternative meet the technical requirements of RCRA. In this way, the cost impact of RCRA compliance on remedial actions can be assessed.

Based on the above, one goal for evaluation of remedial alternatives should, therefore, be to comply with all applicable regulations while minimizing the cost of this compliance. Expression of this goal as a quantitative criterion is difficult since the costs of regulatory compliance can be highly variable. An additional remedial action goal is to have at least one alternative meet the technical requirements of RCRA. The following criteria are offered for general guidance in evaluating methods:

- Regulatory compliance should not constitute a significant increase in costs beyond those required to meet the environmental protection goal.

- At least one alternative shall meet the technical requirements of RCRA.

#### 5.9 Public Acceptance

Public acceptance criteria should address the concerns of the public over implementation of remedial actions, including consideration of those factors perceived by the public as important. Addressing public concerns has proven to be a vital consideration in a number of cases, particularly those involving siting. A major difficulty in dealing with public concerns is that they often are problems of perception, not based on technical considerations; nonetheless, they cannot be dismissed solely on a technical basis.

A goal of remedial action evaluation should be to select an alternative which is acceptable to the public. Expression of this goal in terms of a criterion is difficult since public acceptance often involves intangibles and cannot be quantified. Quantification may best be expressed in terms of cost. The cost of achieving public acceptance is, therefore, addressed by the following criterion:

- The cost of achieving public acceptance of a remedial alternative should not constitute a significant increase in cost beyond that required to meet the primary remedial action goals.

## 6.0 SCREENING OF REMEDIAL ACTION TECHNOLOGIES

Candidate remediation technologies for application to the NWS Concord site are formulated using a two step process: 1) enumeration of available technologies and 2) evaluation of the technology as applied to the site specific attributes and requirements of the NWS Concord site.

### 6.1 Remediation Technologies

The U.S. EPA (1982, 1985) identified 25 major technologies with potential application as remedial actions at hazardous waste sites. The applicability of individual remedial technologies to a particular site is determined by the nature of the contaminant problems and the important migration pathways at the specific site. As noted in several previous studies, Ecology and Environmental (1983), Anderson Geotechnical 1984) Lee, et al. (1986) and Lee, et al. (1985), the contaminants of concern at NWS Concord are heavy metals, primarily arsenic, lead, cadmium, zinc, and selenium. The primary pathway of off site contaminant migration is transport via surface water runoff and erosion processes with subsequent deposition along natural water courses and low lying areas. Secondary pathways of contaminant transport include release of contaminants from the site by wind or direct contact with the site. Leaching of contaminants from the site by surface water infiltration into the groundwater or direct contact with groundwater have not been identified as major migration pathways.

Technologies considered for application at the NWS Concord site are listed in Table 6.1. These technologies are evaluated for applicability to the NWS Concord in section 6.2 of this study. A brief description and evaluation of these remediation technologies is presented below.

6.1.1 Surface Sealing and Capping. Surface sealing and capping is the process by which waste disposal sites are covered to prevent surface water infiltration, control erosion, and isolate and contain contaminated wastes. A variety of impermeable cover materials and sealing techniques is available for such purposes. The choice of sealing material and method of application is dictated by site specific factors such as local availability and cost of cover

Table 6.1  
Potential Remediation Technologies

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Surface Sealing and Capping  
Grading and Revegetation  
Surface Water Diversion and/or Collection  
Containment Barriers  
Hydraulic Barriers  
Excavation and Disposal  
In Situ Treatment  
Bottom Sealing  
Groundwater and Leachate Treatment  
Incineration  
Withdrawal Well Networks  
Flood Proofing  
Permeable Treatment Beds  
Subsurface Collection Drains

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materials, desired function of cover materials, the nature of the waste being covered, local climate and hydrogeology, and projected future use of the site.

Soils used for capping uncontrolled waste sites should be relatively impermeable and erosion resistant. Fine grained soils such as clays and silty clays have low permeability values and are therefore best suited for capping purposes. However, these fine grained materials tend to be easily eroded by wind and water. Blending of soil types can be used to enhance the permeability and erodibility characteristics of capping soils. Cover soil additives such as cements, lime and/or flyash, bitumen (emulsified asphalt or tar), chemical stabilizers (dispersants and swell reducers), and bentonite have also been used to enhance cover soils.

Membrane technologies have also been used as surface treatments. Portland and bituminous concretes and mortars can be mixed and spread over well compacted bases to cover and seal the disposal site. Sprayed bitumen membranes are also available. Synthetic membranes include cover and liner materials made from polyvinyl chloride (PVC), chlorinated polyethylene (CPC), high density polyethylene (HDPE), ethylene propylene rubber, butyl rubber, hypalon, neoprene, and elasticized polyolefin. The use of synthetic liners serve to reduce the profile of the cover system.

Surface sealing and capping technology directly addresses the surface water migration pathway. Since this pathway is a primary concern at the NWS Concord site, the technology will be evaluated further during the initial screening process.

**6.1.2 Grading and Revegetation.** Grading is a general term used to describe techniques to reshape the surface of a site in order to manage surface water infiltration and runoff while controlling erosion. Revegetation decreases erosion by wind and water and contributes to the development of a naturally fertile and stable surface environment. Grading schemes for management of runoff, infiltration, and erosion are usually implemented in conjunction with surface sealing and capping technologies and may be an integral part of revegetation schemes. Slopes of at least 5 percent are recommended as sufficient to decrease infiltration without risking soil erosion. Where off site



transport of contaminated soil due to water erosion is a major consideration, the length of graded slopes should be minimized. Grading and revegetation are routinely applied to upland sites; however, the general concept can be expanded to include marsh restoration as a remedial action alternative.

Remedial alternatives that incorporate leaving the waste materials on site should include a grading and revegetation scheme. Alternatives that incorporate excavation and off site disposal of contaminated materials may include grading and revegetation as part of a marsh restoration scheme. In any event, grading and revegetation technologies have application at the NWS Concord site and will be evaluated further in the initial screening process.

6.1.3 Surface Water Diversion and/or Collection. Surface water diversion and collection structures are used to provide either short-term or permanent measures to hydrologically isolate waste disposal sites from surface inputs. Surface runoff can be managed so that it does not contribute to leachate generation or erosion of cover materials. Conventional measures used to control flooding, surface water infiltration, and off site erosive transport of contaminated sediments and debris include: dikes and berms, ditches, diversions, and waterways; terraces and benches; chutes and downpipes; levees; seepage basins; and sedimentation basins. At any given disposal site, the most effective method of managing surface flow may be a combination of the above techniques. The selection of individual techniques depends on the size and topography of the site, local climate and hydrology, and soil characteristics. More specifically, the length and steepness of slopes, the frequency and intensity of rainfall, and soil permeability, erodibility, and fertility all affect the choice of type and number of individual structures to be included at a particular site.

Contaminant migration resulting from surface water runoff is identified as a major concern at the NWS Concord site. Since surface water diversion and collection technologies directly address this problem, these technologies will be evaluated for incorporation into remedial action alternatives during the initial screening process.

6.1.4 Containment Barriers. Containment barriers include slurry trenches, grout curtains, sheet piling, or other vertical barriers of low permeability materials. Three configurations of barriers are possible: upgradient of the source, downgradient of the source, and completely around the source. Upgradient barriers are designed to divert ground water around the source of contamination and thereby reduce the volume of water which contacts the waste. Downgradient barriers are designed to control movement of the contaminant plume so that it can be captured by a drain or withdrawal wells. Barriers around contamination sources are designed to completely isolate the source. The appropriate barrier configuration depends on the hydrogeological characteristics of the specific site. Performance of containment barriers depends primarily on how well the barrier can be anchored (keyed) into underlying impermeable materials. In the absence of underlying impermeable materials, hanging barriers can be utilized. If contaminants have a specific gravity greater than ground water, hanging barriers are not effective in preventing contaminant migration. Since in either case there is always the potential for flow underneath the barrier, barriers may be used in conjunction with withdrawal wells to prevent future migration of contaminants.

Containment barriers are generally used to address problems associated with contaminants leaching into the groundwater underlying a hazardous substance disposal site. Since the groundwater migration pathway has not been identified as a major concern at the NWS Concord site, containment barriers will not be considered during the alternative development process.

6.1.5 Hydraulic Barriers. Hydraulic barriers are pumping and/or injection well systems which divert the flow of ground water. Such systems can be a simple single pumping well which creates a cone of depression and draws the contaminant plume toward the well, or a complex series of pumping wells and injection wells for creating large scale cones of depression surrounded by ground-water mounds. In either case the withdrawn ground water is treated and either discharged on the surface or injected into the aquifer.

Hydraulic barriers are generally used to address problems associated with contaminants leaching into groundwaters underlying a waste-disposal site. Since the groundwater migration pathway has not been identified as a major concern

at the NWS Concord site, hydraulic barriers will not be considered during the alternative development process.

6.1.6 Excavation and Disposal. Excavation and disposal involves the removal of hazardous substances from their present location to a better engineered or environmentally less sensitive area. Excavation is a common technique used in earth moving projects. It is widely used to move solids and thickened sludge materials; however, it is not well suited for removal of materials with low solids content. Where off site treatment methods are to be used for land-filled wastes, excavation and transportation of the hazardous substances will be required.

Excavation can be accomplished by a variety of mechanical means. Typical excavation equipment used for remedial actions includes draglines and back-hoes. The nature of some sites at NWS Concord, i.e., wetland, may preclude the use of these traditional excavation techniques. In such cases, hazardous substances can be removed by dredging. Several types of dredges are commonly used, including hydraulic, pneumatic, and mechanical dredges.

Excavation and disposal would remove contaminated materials from the site and prevent continued migration of contamination. This technology would provide a major improvement. However, it would probably not be cost effective for removal of all contaminated material, i.e., removal of low levels of contaminants that have already migrated from major spill areas. In addition, excavation technologies can be environmentally disruptive in sensitive areas such as wetlands.

Several disposal options may be implemented in association with excavation technologies, including: 1) removal to an existing RCRA permitted facility, 2) removal to an off site RCRA permitted facility constructed specifically for NWS Concord wastes, 3) removal to an on site disposal facility constructed to meet RCRA standards, and 4) chemical stabilization and disposal on the existing waste site.

Excavation and disposal technologies also require implementation of waste transportation techniques. Transportation requirements are usually satisfied

by the use of plastic lined and covered dump trucks. Typical truck capacities range from 20 to 30 cubic yards. Care must be taken to ensure that the transportation of hazardous substances does not result in spread of contamination along the route of travel. Fugitive dust control is extremely important in both the excavation and transportation process.

Since the excavation and disposal technologies directly addresses the problem of contaminant migration and could potentially provide a major improvement in site conditions, it will be evaluated further as a candidate element in a remedial action alternative.

6.1.7 In Situ Treatment. An alternative to hazardous substance removal is to treat the hazardous substances in-place. A number of conceptual techniques have been proposed as "in situ" treatment methods. These techniques may be feasible for sites where hazardous substances are well defined, shallow, and the extent of contamination is small. In situ treatment has been demonstrated for application to liquids and light sludges. However, it has not been demonstrated for addressing contaminated soils. In situ treatment would solidify or fix contaminants in a matrix that would resist subsequent leaching or movement. Both chemical and physical methods of in situ stabilization have been attempted. There are five major categories of in situ treatment: extraction, immobilization, degradation, attenuation, and reduction of volatilization (USEPA 1984). Most methods involve application of absorbents or chemical reagents and thorough mixing with the contaminated soil. Liming for pH control and adjustment of soil moisture content to optimize treatment conditions is also practiced. Physical stabilization using in situ vitrification (accomplished by applying high voltage via soil electrodes) has also been attempted. Most in situ treatment methods have not been demonstrated in field scale projects. Some successes have been reported in heavy metal immobilization by liming or addition of organic agricultural by products.

There is some concern that such techniques may not be appropriate for sites where numerous metals may be present. This is particularly true for sites where arsenic is mixed with other heavy metals. In such cases, raising the pH to decrease the mobility of the other metals may increase the mobility of

arsenic. In addition, chemical treatment would have to be repeated on a periodic basis.

In situ treatment technology is not deemed to be sufficiently developed for use at NWS Concord. Therefore, in situ treatment will not be evaluated in detail.

6.1.8 Bottom Sealing. Bottom sealing is a concept for the installation of a horizontal barrier underneath the hazardous substances without disturbing the wastes. The concept is analogous to the construction of a horizontal slurry trend. The most common method proposed for bottom sealing is grout injection. Conceptually, this element would prevent or minimize groundwater from rising and falling through the hazardous substances resulting in plume development. The concept of bottom sealing has not been demonstrated at the project level. The process is expected to be very costly because of the requirement to drill grout injection wells through the waste at close intervals. Furthermore, the effectiveness of bottom sealing cannot be assured, i.e., the quality of sealing cannot be predicted or assessed with any degree of accuracy. Further consideration of this element is not included in this study because it is not considered to be a demonstrated technology.

6.1.9 Groundwater and Leachate Treatment. Alternatives incorporating collection of leachate and/or contaminated ground water require treatment of the recovered liquids to acceptable levels of water quality. Since leachate production and groundwater contamination do not appear to be a problem at NWS Concord, this technology is not evaluated in detail.

6.1.10 Incineration. Alternatives incorporating excavation could consider the use of incineration as the hazardous substances disposal method. Incineration technologies are used primarily for the destruction of organic wastes with some heat value. Incineration is not appropriate for heavy metal contaminated wastes. Since the primary problems at the NWS Concord are related to heavy metal contamination, incineration cannot be considered an applicable technology. Therefore, incineration will not be evaluated in detail.

6.1.11 Withdrawal Well Networks. A system of wells with interconnecting cones of depression can be constructed such that ground water flow is diverted or captured. Water withdrawn from the aquifer is routed to a treatment facility for discharge to surface waters or injection into the ground water aquifer. Withdrawal wells are directed to containment of contaminated ground water plumes. Since ground water contamination is not a major concern at NWS, Concord withdrawal well networks will not be evaluated in detail.

6.1.12 Flood Proofing. Portions of the NWS Concord are located in tidal marshes or wetlands. Other areas are in upland areas that may be subject to periodic inundation. Inundation expected at NWS Concord is expected to be less catastrophic than traditional flood events associated with inland streams and rivers. Tidal inundation will be of more significance than stream flood events. Flood proofing is not a major concern at NWS Concord; however, flood proofing may be used in conjunction with surface water diversion to prevent severe erosion. Therefore, a detailed evaluation of flood proofing measures will be considered in proposed remedial action alternatives if appropriate.

6.1.13 Permeable Treatment Beds. Permeable treatment beds are constructed in the path of contaminated groundwater plumes as in situ treatment units. Contaminated ground water flows through the bed and the contaminant is removed or neutralized depending on the medium employed. The active medium may be an absorbent, an ion exchanger, or a reactant capable of insolubilizing or converting the contaminant to a less hazardous form. For heavy metals, ion exchange is the only viable medium. The advantage of permeable treatment beds is their avoidance of requirements for pumping and construction of a containment vessel. The disadvantage is the inability to regenerate the medium without physically removing it. Hence, permeable beds are best utilized in cases where contamination is at low levels so that media will not have to be regenerated during the life of the project. Ground water contamination is not a major concern at NWS Concord. Therefore, permeable treatment bed technology will not be evaluated in detail.

6.1.14 Subsurface Collection Drains. Another commonly employed ground-water recovery technique is the subsurface collection drain. Such drains consist of gravel-filled trenches usually lined with tile or perforated pipe which

intercept the water table. The leachate and contaminated ground water infiltrate into the drain where the water is recovered by pumping and then treated and discharged. Subsurface collection drains can be employed to draw off leachate or infiltrate to prevent it from reaching groundwater and creating a plume. Collection drains can also be employed to lower the water table or draw plumes away from containment barriers.

## 6.2 Summary of Applicable Technologies

The applicability of the candidate remedial technologies evaluated in section 6.1 is summarized in Table 6.2. The technologies found to be applicable to NWS Concord will be used to formulate appropriate remedial action alternatives.

Table 6.2  
Applicability of Remedial Technologies

Available Technology	Applicability At NWSC	
	Yes	No
Surface Sealing and Capping	x	
Grading and Revegetation	x	
Surface Water Diversion and/or Collection	x	
Containment Barriers		x
Hydraulic Barriers		x
Excavation and Disposal	x	
In Situ Treatment		x
Bottom Sealing		x
Groundwater and Leachate Treatment		x
Incineration		x
Withdrawal Well Networks		x
Flood Proofing	x	
Permeable Treatment Beds		x
Subsurface Collection Drains		x



## 7.0 REMEDIAL ACTION ALTERNATIVES

For the purposes of the initial screening process, the candidate technologies identified in Section 6 and the no action alternative can be classified into five functional groups. These include:

- a. No Action
- b. Increased Monitoring
- c. Source Removal
- d. Source Isolation
- e. Site Restoration

The objective of the initial screening process is to reduce the number of alternatives for detailed analysis to the minimum number possible. The approach used in meeting this objective involves classifying alternatives according to functional features and making a relative comparison among the alternatives in each classification. The relative comparisons are based on an evaluation of the environmental effects, environmental protection, and the projected implementability/reliability of the proposed alternatives. The initial screening process does not address the economic feasibility of the alternatives. As a result of the initial screening process the detailed evaluation process can be directed toward clearly superior alternatives in each classification.

### 7.1 Alternative 1. No Action

7.1.1 Alternative Description. The no action alternative involves no additional remediation activities. The various contaminated areas will be left in the "as is" condition. No additional monitoring would be implemented. There will, however, be some miscellaneous site activities that should be implemented. For example, contaminated areas should be posted, property

inventories should be appropriately annotated, etc. Actual on site work will be limited to posting contaminated areas.

7.1.2 Implementation of Alternative 1. The major steps in implementing the no action alternative are:

- a. Development of a contaminated area notification plan,
- b. Posting the contaminated area with appropriate signs,
- c. Annotation of property records, as appropriate, and
- d. Annual inspection and maintenance of posted areas.

7.1.3 Environmental Effects. Under the no action alternative, contaminants would continue to migrate from the various contaminated sites through the pathways described in Section 3. The areal extent of contamination would increase and spread into Suisun Bay. While the concentrations of contaminants might be attenuated by natural dilution processes a wider range of fish and wildlife will be exposed to contaminants. In addition, the potential for large discharges of sediment sorbed contaminants will continue to exist whenever a storm or abnormal high tides occur at NWS Concord. Such events will expose fish in Suisun Bay to toxic materials. The potential environmental effects of the no action alternative are addressed in Lee, et al. (1986, 1985).

7.1.4 Environmental Protection. Obviously, the no action alternative provides no enhancement of environmental protection. This alternative provides no environmental protection. It allows continued migration of contaminants via all pathways, although some protection against direct human contact may be realized by reduction of access to the sites through posting. Endangered species will continue to be exposed to toxic materials remaining on site.

7.1.5 Implementability/Reliability. Since no construction is anticipated, no special problems with implementing the construction or the reliability of the alternative are anticipated. However, regulatory concerns and the degree of public acceptance of the no action alternative may preclude its implementation.

7.1.6 Summary. Based on the evaluation of the environmental effects associated with the no action alternative (Lee, et al. 1986, Lee et al. 1985), it is clearly inadequate to meet appropriate environmental goals and objectives.

## 7.2 Alternative 2. Increased Environmental Monitoring

7.2.1 Alternative Description. The increased monitoring alternative features the no action alternative, i.e., no additional remedial action measures (except posting of contaminated areas) combined with an increased level of environmental monitoring. Contaminated materials would be left in place. An environmental monitoring program would be implemented to periodically evaluate the environmental status of the contaminated areas. This monitoring program would be oriented to the analysis of environmental changes caused by the expected continued migration of contaminants from the areas of concentrated contamination. At a minimum, this environmental monitoring program would include surface water sampling, sediment sampling, bioassays, and wildlife and habitat evaluations.

The increased environmental monitoring alternative (Alternative 2) implements a program of site surveillance and monitoring of soil, water, air, and biota in parcels 579D, 576, 575, 574, 573, 572, 571 and 581. Monitoring will be conducted in two parts.

Part 1 includes the analysis of surface soil samples from the 0 to 6 inch depth every two years. Sampling locations should correspond as closely as possible to those locations sampled by Lee et al. (1986) as well as extending over the remainder of the parcels in the direction of surface contaminant migration. Analyses should include lead, cadmium, selenium, copper, zinc, and arsenic. Soil metal concentrations will be compared to previous samples. Additional plant and earthworm bioassays should be conducted on soil sample locations showing elevated contaminant concentrations to determine potential bioavailability.

Part 2 sampling and associated studies should be conducted at appropriate times during each year. Surface water sampling should be conducted during periods of rainfall runoff and during extreme high tides to determine

contaminant releases through the surface water pathway. Air sampling should be conducted during the driest periods of the year when fugitive dust is expected to be most prevalent. At a minimum, wildlife studies should include animal use of contaminated areas.

A report would be prepared describing the results of sampling and making recommendations for any required remedial actions. The report will also contain an assessment of physical changes in the contaminated areas, i.e., natural improvement or degradation in habitats, man-made alterations to the sites, etc.

7.2.2 Implementation of Alternative 2. The major steps required for implementing this alternative are:

- a. Design of a detailed sampling and analysis program;
- b. Development of action levels and associated responses;
- c. Conduct of a systematic sampling and analysis program; and
- d. Implementation of additional remedial actions as required.

7.2.3 Environmental Effects. Under the increased monitoring alternative, contaminants will continue to migrate from the areas of major contamination and the areal extent of contamination will continue to expand. However, there will be some attenuation of the high contamination levels because of dilution effects. The potential environmental effects are essentially the same as those found in the no action alternative which are fully addressed in Lee, et al. (1986) and Lee, et al. (1985). The threat of contamination of plants and wildlife including endangered species will continue and will increase because of the projected increase in the areal extent of contamination.

7.2.4 Environmental Protection. The increased environmental monitoring alternative provides only limited positive environmental protection benefits above those provided by the no-action alternative. The increased monitoring alternative will not eliminate or mitigate contamination of surface waters, soils, or sediments by continued migration of contaminants from those areas of identified high contaminant concentrations. The implementation of an

environmental monitoring program will, however, provide documentation of continued contaminant migration and its associated environmental impact. Wildlife studies will document species use of the site, the contamination of collected species, and problems caused by continued exposure to the hazardous substances remaining on site. The environmental monitoring program will also provide an early warning of changes in conditions that may increase the potential for substantial environmental damage by continued contaminant release or an unexpected increase in the rate of release.

7.2.5 Implementability/Reliability. Since no construction is anticipated, there are no special problems associated with the implementation or reliability of this alternative. However, there may be some regulatory or public perception of inaction if actual cleanup activities are not implemented. The monitoring program itself should be highly reliable in providing environmental data. Data interpretation and determination of action trigger levels and appropriate responses may be difficult, however.

7.2.6 Summary. The monitoring program alternative is clearly inadequate to address substantial concerns about existing or potential environmental impacts of the contamination. However, certain aspects of the monitoring effort should be incorporated into the more complete remedial action alternatives. The increased monitoring program will be evaluated in detail to serve as a sub-element of the positive remedial action alternatives discussed below.

### 7.3 Alternative 3. Source Removal

7.3.1 Alternative Description. There is only one basic alternative involving source removal, i.e., excavation. There are, however, several options for the disposal of the excavated hazardous substances. These options include:

a. Alternative 3A. Excavation and off site disposal in an existing licensed landfill facility.

b. Alternative 3B. Excavation and off site disposal in a licensed landfill facility constructed specifically for NWS Concord hazardous substances.

c. Alternative 3C. Excavation and disposal at a site on NWS, Concord property that meets RCRA requirements.

d. Alternative 3D. Excavation, chemical solidification/stabilization, delisting and placement in a selected hazardous substance disposal area.

The object of the excavation alternative is to remove the contaminated material from the pathways of migration and to dispose of it in an acceptable manner. Application of this alternative is complicated at NWS, Concord because some of the contaminated sites are located in wetlands, and because Federally and State protected wildlife species are known to inhabit the sites. Because of these concerns, the restoration alternatives were developed and must be considered in the alternative selection process.

Before the various components can be developed in detail, it is necessary to estimate the volumes of materials that would have to be excavated and transported to off site disposal areas. Lee, et al. (1986) estimated the extent of contaminated areas that should be subjected to remedial actions. Seven sites were identified as candidate areas for remediation. The sites and areas of contamination are tabulated below.

<u>Area</u>	<u>Acres Requiring Remediation</u>
ES (parcel 579d)	1.41
(parcel 576)	0.63
G1 (parcel 575)	1.60
K2 (parcel 573)	3.77
(parcel 574)	2.79
KS (parcel 572)	8.15
AB (parcel 572)	8.68
AA (parcel 572)	20.75
CP (parcel 581)	3.50
Canal Pier 4 (parcel 571) <sup>1</sup>	2.43

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<sup>1</sup> Canal Pier 4 area contamination is not considered in this feasibility study.

Contamination was found on the surface, generally between 0 and 18 inches in depth. In addition, contamination was found in piles of excavated soil generated from drainage way maintenance activities. A summary of the quantities for excavation, backfilling, off site transport, disposal, and grading and revegetation are presented in Table 7.1.

7.3.1.1 Description of Alternative 3A. The excavation and off site disposal option consists of excavating contaminated materials followed by burial at a RCRA permitted off site facility. It is assumed that an appropriate facility can be located within 100 miles (round trip) of NWS Concord. The primary means of transportation will be in plastic lined dump trucks. The excavation would be backfilled to surrounding natural marsh elevations, regraded, and revegetated. The major components of this alternative consists of the excavation of contaminated material, off site transportation of contaminated materials, and off site disposal of contaminated materials.

7.3.1.2 Implementation of Alternative 3A. The major steps in implementing the excavation and off site disposal alternative are:

- a. Site preparation and support facilities;
- b. Excavation and transport of contaminated materials to a licensed disposal area,
- c. Backfilling excavated areas with clean material,
- d. Grading and revegetation, and
- e. Operation and maintenance.

Site Preparation and Support Facilities. The various sites would be prepared for construction activities by performing a detailed ground survey of each site and constructing access roads, haul roads, and parking areas. An equipment/personnel decontamination area would be constructed near the entrance to each site. This facility would be equipped with a high-pressure spray washer. Cleaning water would be collected and either treated or shipped off site if required. Trailers would be brought to the site as required to provide space for offices, locker rooms, and storage as required. Portable chemical toilets would be used to satisfy sanitary requirements.

Table 7.1  
Quantities Required for Implementation of Alternative 3A

Item Number	Item Description	Unit <sup>1</sup>	Quantities by Area					AA & AB
			ES	GI	K2	KS	CP	
1	Site Preparation	LS	1	1	1	1	1	1
2	Excavation	CY	3292	2582	10584	19723	5647	47481
3	Backfilling	CY	3292	2582	10584	19723	5647	47481
4	Transportation	CY	4608	3614	14817	27613	7906	66473
5	Off Site Disposal	CY	4608	3614	14817	27613	7906	66473
6	Grading and Revegetation	SY	14249	11664	39278	47791	22547	157938

<sup>1</sup> LS: Lump Sum  
CY: Cubic Yard  
SY: Square Yard



Excavation and Transport. Excavation and transport of the contaminated materials present a number of potential problems with respect to implementation. In wetland and upland areas, the major concerns are the health and safety aspects associated with the excavation of contaminated materials. The primary hazard is the inhalation of dust containing contaminants. Workers will require respiratory protection from fugitive dust. In addition, dust suppression activities should be employed to prevent the spread of contaminated materials. In wetland areas, an added concern is the load bearing capacity of the materials being excavated. For example, poor load bearing materials may require the use of complex excavation schemes or site dewatering. It is believed that appropriate project scheduling could eliminate either of these possibilities.

Hazardous substances would be removed from the site as they are excavated. Transportation and requirements include the absence of free liquids. Excavation in wetland areas may require stockpiling and air drying of some materials. The beds of trucks used to haul contaminated material should be lined and covered to prevent leakage or loss of materials during transportation. Trucks should be decontaminated after loading and prior to leaving contaminated areas. State and Federal transportation regulations would dictate the size of trucks and loads that could be carried. It is assumed that a 30 cubic yard dump truck is the largest truck that could be used.

It is assumed that all excavated material will be transported to a RCRA standard disposal facility. A further analysis of contaminated soils should be accomplished to further define those materials that must be placed in a RCRA facility and those that can be placed in landfills with less stringent requirements which are presumably less costly. Excavated materials can be analyzed and sorted for transport to an appropriate class disposal facility.

Backfilling with Clean Soil. Backfilling of the excavation will be required to return the site to its natural contours. Several problems associated with the backfilling operation may impair implementation of this alternative. It is assumed that an acceptable source of clean soil of the proper type can be found within a reasonable distance from the site. Soil amendments may be necessary. Fill material would have to be tested to obtain

specifications for compaction. Specifications for compaction would have to address potential difficulties of operating compaction equipment within the excavated areas. Operation of backfilling equipment within the wetland area will be extremely critical and care must be taken to ensure minimum disturbance of uncontaminated areas. Seasonal scheduling will be required during backfill operations. Because some contamination is being left in place, the health and safety concerns for the excavation phase also apply to the backfilling phase.

Grading and Revegetation. Grading and revegetation of upland areas will be a rather straightforward construction task. Grading and revegetation of the wetland areas will be more complex and may require more "hand work." Proper scheduling of construction activities can be used to minimize the required amount of "hand work." Care must be taken to insure that vegetation selected for planting is compatible with the area. Of particular concern is final elevation obtained and the selection of vegetation for the wetland areas. Final elevations must be appropriate for the target wetland species.

Operation and Maintenance. The operation and maintenance requirements associated with Alternative 3A are minimal. The operation and maintenance program will be conducted for 5 years. Maintenance will consist of an annual inspection and implementation of required corrective actions to ensure that the grading and revegetation are successful. Particular attention will be given to erosion control and vegetation colonization. Operations will include a 5 year program of environmental monitoring including surface water, sediment, ground water, and wildlife studies (described in Alternative 2). Environmental monitoring program will also include an evaluation of those contaminated areas not selected for active remediation at this time. If environmental monitoring shows a reduction in contaminant migration, all operation and maintenance will be discontinued after 5 years.

7.3.1.3 Description of Alternative 3B. An alternative to disposal in an existing RCRA facility is to construct an off site RCRA facility specifically for the contaminated materials removed from the NWS Concord. The proposed facility would be constructed in accordance with all applicable regulations, both substantive and procedural. The major components of this alternative

include the excavation of contaminated material, backfilling of the excavated areas to natural land elevations, site grading, site revegetation, off site transportation of contaminated materials, and construction and operation of an approved disposal facility.

7.3.1.4 Implementation of Alternative 3B. The major steps in implementing Alternative 3B are:

- a. Development of an off site disposal facility;
- b. On site preparation and support facilities;
- c. Excavation and transport of contaminated materials to the newly constructed facility;
- d. Backfilling excavated areas with clean material;
- e. Grading and revegetation;
- f. Operation and maintenance of on site facilities; and
- g. Operation and maintenance of off site disposal facilities.

Development of an Off Site Disposal Facility. Alternative 3B includes the development of an off site disposal facility for the excavated contaminated materials. It is assumed that the facility will be required to meet RCRA standards. A schematic of the facility is shown in Figure 7.1. The facility will require the acquisition of approximately 15 acres of land. In addition, an extensive licensing and permitting procedure will be required.

On Site Preparation and Support Facilities. See Alternative 3A.

Excavation and Transport. See Alternative 3A.

Backfilling with Clean Soil. See Alternative 3A.

Grading and Revegetation. See Alternative 3A.

Operation and Maintenance of On Site Facilities. See Alternative 3A.

Operation and Maintenance of Off Site Facilities. Since Alternative 3B includes the development of an off site disposal facility, operation and maintenance of the off site facility after completion of the disposal activities must be considered. It is assumed that the facilities will be operated in accordance with RCRA regulations which require extensive maintenance and monitoring activities.

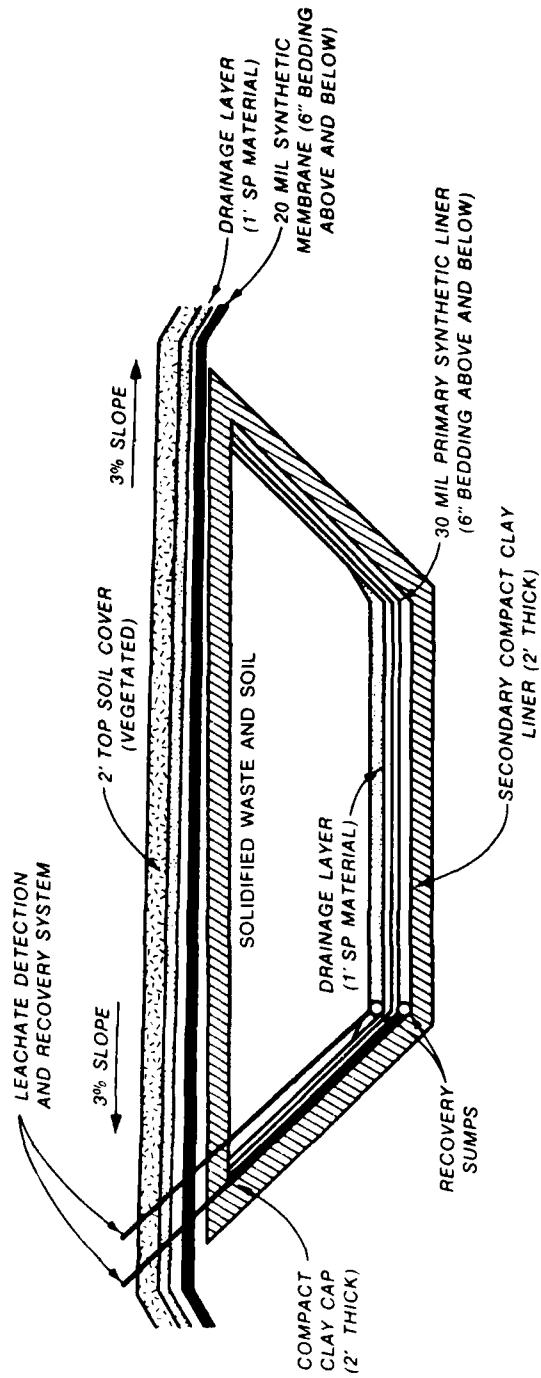


Figure 7.1. Engineered disposal facility.

7.3.1.5 Description of Alternative 3C. An alternative to off site disposal is construction of an engineered disposal facility on NWS Concord land. Parcel 581, the Coke Pile (CP) area is proposed as an appropriate location for such a facility. Other areas may be evaluated during the concept development phase. The major components of this alternative include the excavation of contaminated material, backfilling of the excavated areas to natural land elevations, site grading, site revegetation, transportation of contaminated materials to the CP area, and construction and operation of an approved disposal facility in the CP area.

7.3.1.6 Implementation of Alternative 3C. The major steps in implementing Alternative 3C are:

- a. Development of an approved disposal facility in the CP area;
- b. On site preparation and support facilities;
- c. Excavation and transport of contaminated materials to the newly constructed facility;
- d. Backfilling excavated areas with clean material;
- e. Grading and revegetation;
- f. Operation and maintenance of on site facilities; and
- g. Operation and maintenance of the on site disposal facilities.

Development of an On Site Disposal Facility. Alternative 3C considers the development of an on site disposal facility for the contaminated materials excavated from the remaining sites. The facility would be constructed in accordance with state and Federal requirements. It is assumed, for purpose of the feasibility study, that the disposal facility would be designed to meet RCRA requirements as illustrated on Figure 7.1. The facility will require approximately 15 acres of land to handle the estimated 125,000 cubic yards of contaminated material to be excavated from the NWS Concord.

On Site Preparation and Support Facilities. See Alternative 3A.

Excavation and Transport. See Alternative 3A.

Backfilling Excavated Areas. See Alternative 3A.

Grading and Revegetation. See Alternative 3A.

Operation and Maintenance of On Site Facilities. See Alternative 3A.

Operation and Maintenance of On Site Disposal Facility. Alternative 3C requires the operation and maintenance of an on site disposal facility. It is assumed that the disposal facility will be operated in the same manner as presented under Alternative 3B.

7.3.1.7 Description of Alternative 3D. An alternative to disposal in a RCRA licensed facility is excavation, stabilization, delisting, and disposal in a sanitary landfill or a waste soil disposal area. The delisting process effectively changes the hazardous nature of the contaminated material, permitting it to be handled as a non-hazardous material. The major components of this alternative include the development of an effective chemical stabilization process, delisting of the contaminated materials, excavation and stabilization of the excavated materials, transportation of the contaminated materials to an appropriate disposal area, backfilling of excavated areas, site grading, site revegetation, and construction of a contaminated material disposal area or transport to a sanitary landfill.

7.3.1.8 Implementation of Alternative 3D. The major steps in implementing Alternative 3D are:

- a. Development of a stabilization process;
- b. Delisting of the hazardous substances;
- c. On site preparation and support facilities;
- d. Excavation and transport of contaminated materials to an appropriate disposal area;
- e. Stabilization of contaminated materials;
- f. Backfilling excavated areas with clean material;
- g. Grading and revegetation;
- h. Operation and maintenance of on site facilities; and
- i. Operation and maintenance of on site disposal area or transport to an off site landfill.

Development of a Stabilization Process. The primary contaminants found in the materials are the toxic metals and arsenic. Chemical solidification/stabilization has been proposed as a treatment method for immobilization of toxic metals. Arsenic, however, has proven to be difficult to immobilize.

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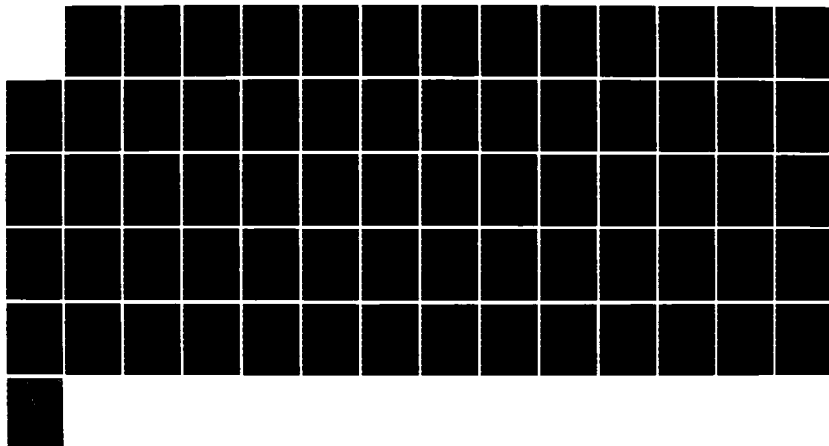
FEASIBILITY STUDY OF CONTAMINATION REMEDIATION AT NAVAL 2/2

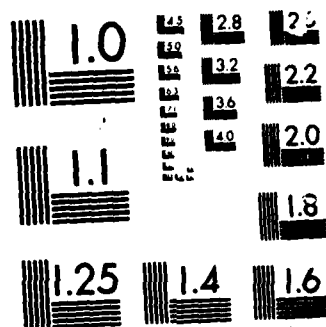
WEAPONS STATION C. (U) ARMY ENGINEER WATERWAYS

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MICROCOPY RESOLUTION TEST CHART  
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Typical solidification/stabilization methods include cement or pozzolanic processes. Typical solidification/stabilization processes require the addition of 25 to 100% by weight of chemicals. In the case of contaminated soils, it may be necessary to add water to assure that reactions occur. Wetland soil material will have extremely high concentrations of organic matter that may be difficult to stabilize.

Delisting. Appropriate regulatory agencies will be contacted to determine disposal requirements for the stabilized materials. Although formal delisting may not be required, it is believed that regulatory agencies will require some special handling of materials.

On Site Preparation and Support Facilities. See Alternative 3A.

Excavation and Transport. See Alternative 3A.

Stabilization of Contaminated Material.

Backfilling of Excavated Areas. See Alternative 3A.

Grading and Revegetation. See Alternative 3A.

Operation and Maintenance of On Site Facilities. See Alternative 3A.

Operation and Maintenance of On Site Disposal Facility. Delisting effectively changes the regulatory nature of the contaminated materials. After stabilization, the materials would be amenable to on site disposal or disposal in a landfill. If on site disposal is chosen, the disposal area will require operation and maintenance. This will include maintenance of a cap over the material and site monitoring. If disposal in a landfill is chosen, operation and maintenance of disposal facilities will not be required.

7.3.2 Environmental Effects. All excavation alternatives present the potential for adverse environmental effects caused by exposure to the excavated material of construction personnel and persons located off site during transportation. The excavation of contaminated material will also severely impact if not temporarily destroy the important wetland habitat found at Site AA and AB on Parcel 572 and will severely impact resident wildlife populations by death or displacement. Over time, the site of the excavation will silt in and vegetation will recolonize. In the short term, the habitat will be either a mudflat or standing water, depending on elevation and drainage. Neither of these types will provide habitat for the protected species currently on site

(Lee et al. 1985). These adverse short term impacts will be mitigated by the potential for long term recovery of the area once the contaminated material is removed. Anticipated short term impacts can be minimized by relocating any endangered species. Prior to excavation, the endangered salt marsh harvest mouse should be trapped and removed from construction areas on sites KS, AA, and AB. A suitable wetland should be located for placement of the collected animals prior to trapping.

The off site disposal options have the additional risk of exposure of the public to contaminated material during the transport of the materials to the disposal area.

7.3.3 Environmental Protection. The excavation and off site disposal alternative (either at existing licensed landfills or a specially constructed landfill) or the on site disposal in a specially designed landfill should provide approximately the same level of environmental protection. Environmental protection provided by the excavation and delisting option cannot be assessed; however, it is anticipated to be significantly less than that afforded by the other options. Long term environmental protection, however, is provided at the expense of rather severe short term environmental impacts. This is particularly true in the wetland area (Sites KS, AA and AB on Parcel 572). In the long term, natural regrowth of the contaminated wetland and upland areas should substantially mitigate the short term damage; however, this length of time required for this to occur cannot be quantified.

7.3.4 Implementability/Reliability. The excavation and off site disposal options should be very reliable. In effect, the contaminated materials will be removed from the site. The reliability of the excavation and on site disposal alternative will be somewhat less than the off site disposal alternative. The reliability of the delisting option cannot be assessed since the availability of a stabilization process has not been determined. In developing the stabilization alternative concept, it was assumed that a cement-pozzolan mix could be formulated that would both solidify and stabilize the contaminated soil materials. Additional tests would have to be performed to determine if such a mix can be developed. Classically, arsenic has proven to be difficult to stabilize.

The major difficulties with implementation of the excavation and off site disposal alternatives are the problems associated with transportation of large quantities of contaminated materials and the potentially severe short term impacts on environmentally sensitive areas. Because of the expected long haul distances, a large number of trucks will be required. Transportation safety will be a major concern, although not sufficient to cause rejection of the alternative.

Regulations regarding wetland destruction and harm to endangered species and their habitat will hinder implementation. Close coordination with an approval of regulatory and resource management agencies will be required if this alternative is selected. Trapping and removal of endangered species will be required prior to excavation. A suitable wetland should be found for relocation of the endangered species during construction activities.

Implementation of the excavation and on site disposal and/or delisting alternatives is complicated by the stringent regulatory requirements associated with such activities. At a minimum, it is expected that 4 years would be required to obtain a permit to construct a new RCRA facility. Delisting would require a similar length of time.

7.3.5 Summary. Four source removal alternatives were initially considered for applicability as a remedial action at NWS Concord. These alternatives included:

a. Excavation and off site disposal in an existing licensed landfill facility.

b. Excavation and off site disposal in a licensed landfill facility constructed specifically for NWS Concord hazardous substances.

c. Excavation and disposal at a site meeting RCRA requirements on NWS Concord property, i.e. probably in Area CP.

d. Excavation, chemical solidification/stabilization, delisting, and placement in a selected hazardous substance disposal area.

Because of time constraints associated with the implementation of Alternatives 3B, 3C, and 3D, only Alternative 3A will be carried forward for detailed evaluation.

#### 7.4 Alternative 4. Source Isolation

7.4.1 Alternative Description. Two source isolation alternatives were considered for application at NWS Concord. These include:

a. A surface treatment incorporating construction of a topsoil cover and site revegetation.

b. A surface treatment incorporating construction of a multilayered cover roughly meeting RCRA requirements and site revegetation.

7.4.1.1 Description of Alternative 4A. This alternative examines the use of a topsoil/vegetative cover to reduce the possibility of erosion and direct contact with the contaminated soil materials. The contaminated soil material located on the various sites will not be removed. A natural soil cover would be placed over the contaminated areas. The primary components of the alternative include the placement of a soil cover, grading, and revegetation of the sites. The quantities of materials required to implement this alternative are listed in Table 7.2.

##### 7.4.1.2 Implementation of Alternative 4A.

The major steps in implementing this alternative are:

- a. Site preparation and support facilities;
- b. Placement of cover, site grading, and revegetation; and
- c. Site maintenance and monitoring.

Site Preparation and Support Facilities. The various sites would be prepared for construction activities by performing a detailed ground survey of each site and constructing temporary access roads, haul roads, and parking areas. An equipment/personnel decontamination area would be constructed near

Table 7.2  
Quantities Required for Implementation of Alternative 4A

Item Number	Item Description	Unit	Quantities by Area						CP	AA & AB
			ES	G1	K2	KS				
1	Site Preparation	LS	1	1	1	1			1	1
2	Initial Site Grading	SY	9874	7744	31751	39446			16940	142441
3	Clean Fill Cover	CY	7033	5567	21969	27190			11882	96647
4	Top Soil Cover	CY	10648	8820	28068	33936			16468	109036
5	Final Grading and Revegetation	SY	15970	13225	42102	50900			24698	163550

the entrance to each site. This facility would be equipped with a high-pressure spray washer. Cleaning water would be collected and either treated or shipped off site if required. Trailers would be brought to the site as required to provide space for offices, locker rooms, and storage as required. Portable chemical toilets would be used to satisfy sanitary requirements.

Placement of Cover, Site Grading, and Revegetation. The various sites would be covered with 2 feet of compacted select fill material and graded to promote runoff. Following grading and compacting, 2 feet of topsoil would be placed uniformly over the sites to facilitate the establishment of vegetation. The addition of 2 feet of top soil will ensure the long term success of the proposed shallow rooted vegetation. The topsoil would be minimally compacted. After topsoil placement is complete, a mixture of shallow-rooted grasses would be established to stabilize the surface against erosion, improve the appearance of the sites, and reduce maintenance requirements.

Site Maintenance and Monitoring. The operation and maintenance program for Alternative 4A will be conducted in perpetuity. Maintenance will consist of an annual inspection and implementation of required corrective actions to ensure that the grading and revegetation efforts are successful. Particular attention will be given to erosion control. Maintenance will be more intensive during the first 5 years or until the vegetative covers are established. Maintenance of the vegetative ground cover (e.g., mowing, seeding and mulching, replacing soil, and fertilizing) may be required to prevent exposure of contaminated materials. Operation will include a program of environmental monitoring including surface water, sediment, ground water, and biota (to include wildlife) (described in Alternative 2). Environmental monitoring will include an evaluation of those contaminated areas not selected for remediation.

7.4.1.3 Description of Alternative 4B. This alternative examines the use of a multilayered cover (RCRA cap) to reduce the possibility of erosion and direct contact with the contaminated soil material. This alternative consists of raising the surface of the sites and regrading to provide a base for a RCRA cap design. The RCRA cap will include a 2 ft thick impermeable ( $10^{-7}$ ) clay layer, a 12 inch drainage layer, a 20 mil synthetic membrane with bedding, and

a 2 ft layer of topsoil. Finally, the cover will be graded and revegetated. A cross section of the RCRA cap is illustrated in Figure 7.2. The quantities of materials required to implement this alternative are presented in Table 7.3.

After the sites have been prepared for cap construction, a 2 ft thick low permeability layer would be placed directly on the prepared surface. It would be placed and compacted to form a continuous blanket with a hydraulic conductivity less than  $10^{-1}$  cm/s. The drainage layer of compacted sand (hydraulic conductivity greater than  $10^{-7}$  cm/2) would be placed on top of the synthetic membrane. The drainage layer would be designed so that collected water flows freely in the lateral direction to minimize the head on the low permeability layer. A 2 ft layer of topsoil would be placed over the drainage layer. This thickness of topsoil would ensure that the impermeable layer and drainage layer are protected from desiccation and other surface activities. The topsoil would also optimize conditions for the establishment of a vegetative cover designed to: stabilize the soil against wind and water erosion; reduce runoff through interception, infiltration, uptake and transpiration; protect the drainage and impermeable layer; improve the appearance of the sites; and reduce long term maintenance requirements.

Construction of the cover would be sequenced to reduce environmental impacts, particularly in the wetland areas. Appropriate erosion control procedures would be implemented during construction to minimize off site migration of contaminants. Cover materials would be transported to the site by truck. Once at the sites, materials would be spread and compacted by conventional earthwork equipment. It is assumed for cost purposes that suitable cover materials can be located within 25 miles of the NWS Concord. The cover materials would be spread in loose lifts 6 to 8 inches deep and compacted to the required density. The sites will be revegetated with plant species suitable for the area. Salt tolerant species will be selected for use in the former wetland areas.

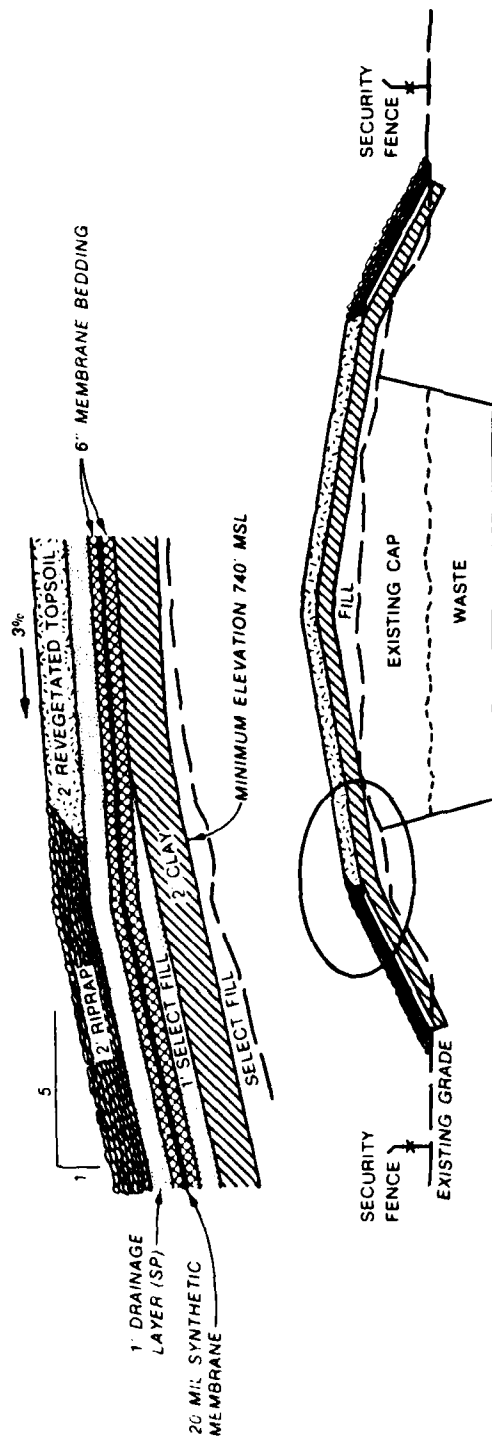


Figure 7.2 Cross section of a multilayered cap.



Table 7.3  
Quantities Required for Implementation of Alternative 4B

Item Number	Item Description	Unit	Quantities by Area					AA & AB	
			ES	GI	K2	KS	CP		
1	Site Preparation	LS	1	1	1	1	1		1
2	Initial Site Grading	SY	9874	7744	31751	39446	16940		142441
3	Impermeable	SY	14249	11664	39278	47791	22547		157938
4	Top Soil Cover	CY	11684	9760	29732	35760	17748		112296
5	Final Grading and Revegetation	SY	17521	14641	44600	53644	26620		168440

#### 7.4.1.4 Implementation of Alternative 4B.

The major steps in implementing this alternative include:

- a. Site preparation and support facilities;
- b. Filling and grading the sites;
- c. Construction of the multilayered cover;
- d. Site maintenance and monitoring.

Site Preparation and Support Facilities. Site preparation and support facilities would be similar to those described in Alternative 4A. Additional geotechnical studies will be conducted to determine the stability of the proposed cover under seismic forces and long term erosion. This will be particularly important in the wetland areas.

Filling and Grading of the Sites. Prior to constructing the RCRA cap, the sites will be graded and filled with compacted select material to provide a suitable structural base for the cap.

Construction of Multilayered Cover. A multilayered cover would be used to reduce surface water infiltration into the disposed materials and to minimize erosion and direct contact with contaminated soil material. The RCRA cap includes four functionally distinct layers. A low permeability layer of clay would be placed over the surface of the sites to minimize surface water infiltration. A synthetic membrane and appropriate bedding would be placed over the synthetic membrane to facilitate drainage of water reaching the surface of the synthetic membrane. The upper most layer of the cover would consist of topsoil supporting shallow rooted revegetation as a protective covering.

Site Maintenance and Monitoring. The site maintenance and monitoring program would be the same as that proposed for Alternative 4A.

7.4.2 Environmental Effects. Although the implementation of surface barriers for source isolation will prevent further migration of contaminants, there will be a long term adverse impact associated with changing the natural elevation of the area. This will be particularly important in the wetland area

(Site AA on Parcel 572). The top soil cover will raise the ground surface elevation a minimum of 4 feet, while the multilayered cover would raise the ground surface elevation a minimum of 6 feet. In both cases, the wetland areas would be destroyed and the remaining wetland reduced in acreage. Regulatory issues will be raised with any proposal to fill and destroy wetlands that results in the loss of habitat and harm to endangered species.

7.4.3 Environmental Protection. Both source isolation alternatives are designed to reduce the possibility of erosion, direct contact with contaminated soil material and uptake by plants and animals. The contaminated soil material would not be disturbed from their current condition. The multilayered cover would have the added advantage of minimizing rain water infiltration and, thus, reducing the possibility that contaminants will be leached from the contaminated areas into the groundwater or drain laterally into the wetland.

7.4.4 Implementability/Reliability. Technically, both the topsoil and multilayered cover alternatives can be implemented. There are minor technical concerns associated with the geotechnical stability of the wetland areas and their ability to support a cover. These concerns would be more important to the construction of the multilayered cover than to the top soil cover. Since at this site the cover is intended only to prevent continued migration via the surface water pathway and direct human and biological contact, the integrity of the cover is not as critical as in those cases where the cover is constructed to prevent infiltration of contaminants into the groundwater. These geotechnical concerns can be addressed during concept development and design phases. Construction of the covers are commonly preformed operations which can successfully prevent contact with contaminated soil material and stabilize the site. With proper maintenance, the life of the surface capping alternatives is expected to be indefinite.

There are minor concerns over erosion from tidal influences. These can be addressed during concept development and preliminary design phases.

The primary impediment to implementation of Alternatives 4A and 4B are the regulatory requirements associated with implementation of remedial actions

in wetland areas. Of particular concern are remediation activities in Areas AA and AB. These concerns are addressed by inclusion of the site restoration alternatives (5A and 5B) in the feasibility study.

7.4.5 Summary. Since ground water contamination does not appear to present a problem at NWS Concord, the top soil cover option should be technically adequate. The multilayered cover could potentially be required by regulation. Both the top soil and multilayered cover will have a severe impact on the wetland area (Site AA on Parcel 572) and for this reason could be eliminated from detailed evaluation. However, either of these alternatives could be an element of a restoration scheme employing mitigation concepts, i.e., purchase of off site wetlands to offset the loss of on site wetlands. Therefore, both source isolation options will be evaluated in detail.

## 7.5 Alternative 5. Site Restoration

7.5.1 Alternative Description. Whereas site remediation emphasizes the cleanup or mitigation of a release of contaminated materials, site restoration emphasizes the return of environmental conditions to a pre-existing condition or enhancement of the environmental conditions. In most cases, it is expected that restoration activities would be more costly than the implementation of remedial activities. However, at the NWS Concord there appears to be a unique opportunity to combine site remediation and environmental restoration while in fact reducing the cost of the underlying remediation activities.

Contaminated areas of NWS Concord include both upland and wetland areas. To simplify the analysis, the seven sites proposed for remediation can be combined into three areas of concern: Area I which includes site CP, Area II which includes sites ES, K2, and G1, and Area III which includes sites AA, AB, and KS. Restoration is primarily a consideration associated with wetland areas, however, restoration of upland areas will also be accomplished. However, restoration of upland areas is considered to be a much easier task. Restoration includes both revegetation and replacement of fauna as may be appropriate. The primary basis for including restoration as an alternative is the conversion of upland habitat into wetland habitat. A further inducement to this activity is the requirement for mitigation of damage that may occur as

a result of remedial activities conducted in wetland areas. Three restoration alternatives were initially evaluated. These include:

a. Alternative 5A. Implement Alternative 4A in Area I and Alternative 3A in Areas II and III. Allow natural wetland revegetation to occur Areas II and III.

b. Alternative 5B. Implement Alternative 4A in Area I, Alternative 3A with an active wetland restoration program in Area III, and Alternative 3A in Area II.

c. Alternative 5C. Implement Alternative 4A in Area I, Alternative 4A in Area II, and Alternative 4A in Area III. Wetland loss in Area III will be mitigated through off site creation of wetlands.

#### 7.5.1.1 Description of Alternative 5A

Area I. Area I is an upland containing approximately 3.5 acres of contaminated surface soils. Since Area I is a relatively insensitive environmental area, Alternative 4A will be implemented in this area.

Area II. Area II consists of upland and fresh water wetland area characterized by Nichols Creek and an unnamed tributary which flow through the area. Area II is primarily a riparian drainageway. A modified Alternative 3A can be implemented in this area.

Implementation of modified Alternative 3A would create a wide freshwater/ riparian wetland along Nichols Creek and unnamed tributary. As a ancillary feature of this alternative, the final grading plan should include creation of a wide freshwater wetland/ sedimentation area on either site G1 or K2. The preferred site would be as far downstream as possible. The wetland/ sedimentation area would trap any further downstream movement of contaminants and prevent movement of contaminants into the environmentally sensitive wetland areas located in site AA.

Area III. Area III is primarily a wetland area. Alternative 3A will be implemented in Area III. Backfilling will be eliminated from the Alternative and a lower elevation wetland will be created in Area III. Natural revegetation will be allowed to occur.

Quantities required for implementation of Alternative 5A are presented in Table 7.4.

#### 7.5.1.2 Implementation of Alternative 5A

The major steps required for implementation of Alternative 5A are:

- a. Site preparation;
- b. Excavation of contaminated materials in Area II and III;
- c. Transportation of contaminated materials to an appropriate commercial disposal site;
- d. Appropriate off site disposal of contaminated materials;
- e. Placement of cover, site grading and revegetation in Area I; and
- f. Site maintenance and monitoring.

Site Preparation and Support Facilities. See Alternative 3A.

Excavation of Contaminated Materials. See Alternative 3A.

Transportation of Contaminated Materials. See Alternative 3A.

Off Site Disposal. See Alternative 3A.

Placement of Cover, Site Grading, and Revegetation. See Alternative 4A.

Site Maintenance and Monitoring. See Alternative 5B.

#### 7.5.1.3 Description of Alternative 5B

Alternative 5B incorporates the concept of full restoration of on site areas. Although both the upland and wetland areas will be restored, particularly attention would be given to restoration of wetland areas. Alternative 5B assumes full implementation of Alternative 5A with an add on restoration element that includes both flora and fauna restoration. A detailed restoration plan would be developed as part of this alternative. The restoration plan would give particular attention to the acquisition and

Table 7.4  
Quantities Required for Implementation of Alternative 5A

Item Number	Item Description	Unit	Quantities by Area						CP	AA & AB
			ES	G1	K2	KS				
1	Site Preparation	LS	1	1	1	1			1	1
2	Initial Site Grading	SY	-	-	-	-			16490	-
3	Excavation	CY	3292	2582	10584	19723			-	47481
4	Transportation	CY	4608	3614	14817	27613			-	66473
5	Off Site Disposal	CY	4608	3614	1987	27613			-	66473
6	Clean Fill Cover	CY	-	-	-	-			11882	-
7	Top Soil Cover	CY	-	-	-	-			16468	-
8	Final Grading	SY	14249	11664	39278	47791			24698	157938
9	Revegetation	SY	-	-	-	-			24698	-

planting of plant species normally found in both upland and wetland areas of the contaminated sites as well as repopulation of animals native to the area. Quantities required for implementation of Alternative 5B are presented in Table 7.5.

#### 7.5.1.4 Implementation of Alternative 5B

The major steps required for implementation of Alternative 5B are:

- a. Site preparation and support facilities;
- b. Excavation and transport of contaminated materials to a licensed disposal area;
- c. Backfilling excavated areas with clean material;
- d. Grading and revegetation of upland areas;
- e. Restoration of wetland area, including flora and fauna;
- f. Placement of cover, site grading, and revegetation in Area I; and
- g. Site maintenance and monitoring.

Site Preparation and Support Facilities. The implementation of site preparation and support facilities is described in Alternative 3A.

Excavation and Transport. The implementation of the excavation and transport step is described in Alternative 3A.

Backfilling. The implementation of the backfilling step is described in Alternative 3A.

Grading and Revegetation of Upland Sites. The grading and revegetation of upland sites is described in Alternative 3A.

Restoration of Wetland Sites. Wetland restoration is a relatively new science. Although wetland restoration will be preceded by development of a detailed wetland restoration plan during the design phase, basic considerations are provided in this report. It is considered plausible and highly probable to restore wetlands on the site if basic habitat requirements are provided for both plants and animals. Josselyn and Buchholz (1982) tabulated



Table 7.5  
Quantities Required for Implementation of Alternative 5B

Item Number	Item Description	Unit	Quantities by Area						CP	AA & AB
			ES	GL	K2	KS				
1	Site Preparation	LS	1	1	1	1			1	1
2	Initial Site Grading	SY	-	-	-	-			16490	-
3	Excavation	CY	3292	2582	10584	19723			5647	47481
4	Backfilling	CY	-	-	-	-			-	47481
5	Transportation	CY	4608	3614	14817	27613			7906	66473
6	Off Site Disposal	CY	4608	3614	14817	27613			7906	66473
7	Clean Fill Cover	CY	-	-	-	-			11882	-
8	Top Soil Cover	CY	-	-	-	-			16468	-
9	Final Grading	SY	14249	11664	39278	47791			22547	157938
10	Revegetation	SY	14249	11664	39278	-			22547	-
11	Wetland Restoration	SY	-	-	-	47791			-	157938

and summarized several successful marsh restoration projects within San Francisco Bay. Certain requirements must be met if native wetland plants and animals are to be restored. Assuming the plants are restored or resemble pre-disturbance conditions, animals formerly occupying the sites should return naturally or remain if re-introduced artificially. A site where natural succession is occurring from a bare dredged material disposal site is a salt pond called Salt Pond #3 near Alameda Creek in south San Francisco Bay. Newling and Landin (1985) described eight years of monitoring this site and conclude the site was adequately vegetated with native, wetland plants and is being used regularly by indigenous wildlife.

Primary requirements for wetlands restoration will be based upon re-establishment of elevations to create a hydrologic regime suitable for indigenous wetland plants. Therefore, special care will be taken in the site grading process to ensure that proper elevations and drainage are maintained. Most salt marsh species such as Pacific cordgrass (Spartina foliosa) and pickleweed (Salicornia spp.) can occur over a broad range of intertidal elevations, but each has a peak abundance in different parts of the marsh. Contouring the topography from mean sea level (MSL) to extreme high water will provide suitable elevations for salt marsh species (Zedler 1984). Indigenous plants such as pickleweed, bulrush (Scirpus balticus), salt grass (Distichlis spicata) and other associated species commonly found in the present marsh will be transplanted from nearby uncontaminated areas. Transplants will be in the form of sprigs, plugs, and rooted stems. Planting on one-half meter centers will require approximately 528,208 wetland transplants. Revegetation will be mechanized to the greatest extent possible, however, considerable hand work may be required. Fill material, provided it is topsoil, should have adequate organic matter and other nutrients essential for plant growth. However, soil amendments such as natural fertilizers (e.g. cow manure) or commercial fertilizers and mulch may have to be added and mixed with the fill material.

Placement of Cover, Site Grading and Revegetation. See Alternative 4A.

Site Maintenance and Monitoring. Maintenance of upland areas consists of periodic inspections (monthly for the first 3-4 months) and then annually to ensure vegetative development is successful. Measures may have to be taken to

ensure plant development. For example, in a dry area such as this, irrigation systems may have to be employed at least until the plants become well established. Periodic overseeding may have to be implemented to ensure better plant coverage. Monitoring-plots for measuring plant coverage and vigor will be established both in the upland and wetland areas to the extent that plots represent a significant sample of both types of areas. Maintenance of wetland areas consists of an intensive effort to ensure success of the restoration effort. Replanting attempts may be implemented in local parts of the wetland areas to ensure coverage of appropriate species that have the habitat requirements found associated with those local parts. Maintenance of upland and wetland areas will be discontinued after five years. Environmental monitoring (described in Alternative 2) will be conducted for five years.

#### 7.5.1.5 Description of Alternative 5C.

Alternative 5C incorporates remediation of on site contamination of implementation of Alternative 4A with off site mitigation of the loss of land, particularly wetlands at sites AA and AB on Parcel 572, by purchase of off site properties. Quantities associated with implementation of Alternative 5B are presented in Table 7.5

#### 7.5.1.6 Implementation of Alternative 5C.

The major steps in implementing this alternative are:

- a. Obtaining off site mitigation lands;
- b. Site preparation and support facilities;
- c. Placement of cover, site grading, and revegetation;
- d. Site maintenance and monitoring.

Site Preparation and Support Facilities. The various sites would be prepared for construction activities by performing a detailed ground survey of each site and constructing access roads, haul roads, and parking areas. An equipment/personnel decontamination area would be constructed near the entrance to each site. This facility would be equipped with a high-pressure spray washer. Cleaning water would be collected and either treated or shipped

Table 7.6  
Quantities Required for Implementation of Alternative 5C

Item Number	Item Description	Unit	Quantities by Area					
			ES	GI	K2	KS	CP	AA & AB
1	Site Preparation	LS	1	1	1	1	1	1
2	Initial Site Grading	SY	9874	7744	31751	39446	16940	142441
3	Clean Fill Cover	CY	7033	5567	21969	27190	11882	96647
4	Top Soil Cover	CY	10648	8820	28068	33936	16468	109036
5	Final Grading and Revegetation	SY	15970	13225	42102	50900	24698	163550
6	Off Site Mitigation Lands	AC	3.30	2.73	8.70	10.52	5.10	34.80
7	Wetland Restoration for Off-Site Lands	SY	-	-	-	50916	-	163550

off site if required. Trailers would be brought to the site as required to provide space for offices, locker rooms, and storage as required. Potable chemical toilets would be used to satisfy sanitary requirements.

Placement of Cover, Site Grading and Revegetation. The various sites would be covered with 2 feet of compacted select fill material and graded to promote runoff. Following grading and compaction, 2 feet of topsoil would be placed uniformly over the sites to facilitate the establishment of vegetation. The topsoil would be minimally compacted. After topsoil placement is complete, a mixture of shallow-rooted grasses would be established to stabilize the surface against erosion, improve the appearance of the sites, and reduce maintenance requirements.

Obtaining Off Site Mitigation Lands. The results of the remedial investigation indicate that approximately 109.47 acres have been impacted by the release of contamination. Of these, approximately 54 acres including approximately 45.32 acres of wetland, were selected for implementation of remediation activities. Loss of the use of these important wetlands will be mitigated through replacement of on site wetlands with off site wetlands. The search for suitable mitigation lands must use criteria such as similarity of habitat type, surrounding land use conditions, adequate acreage, and the ability to maintain or improve habitat conditions. An attempt to identify and acquire similar wetlands will be made; however, if these are not available, it is proposed that available agricultural lands be converted into wetlands.

Site Maintenance and Monitoring. The operation and maintenance program for Alternative 5C will be conducted in perpetuity. Maintenance will consist of an annual inspection and implementation of required corrective actions to ensure that the grading and revegetation efforts are successful. Particular attention will be given to erosion control. Maintenance will be more intensive during the first 5 years or until the vegetative covers are established. Maintenance of the vegetation ground cover (e.g., mowing, seeding and mulching, replacing soil, and fertilizing) may be required to prevent exposure of contaminated materials. Operation will include a program of environmental monitoring including surface water, sediment, ground water, and biota (to

include wildlife) (described in Alternative 2). Environmental monitoring will also include an evaluation of those contaminated areas not selected for remediation.

7.5.2 Environmental Effects. In the long term, the goal of restoration is to minimize the environmental effects of contamination and remedial action. There may be some rather severe short term environmental effects associated with required construction activities. Restoration on site will return the site to an acceptable condition. Mitigation for loss of on site wetland habitat will result in overall preservation of similar habitat in the region.

Alternative 5A relies on natural processes for the restoration of wetland vegetation in Areas II and III. Area I will be revegetated with appropriate upland vegetation as part of the remediation process. Since Alternative 5A does not include backfilling, Areas II and III will probably return with different species. It is believed that natural wetland restoration will require 5 to 10 years.

Alternative 5B incorporates active wetland restoration processes for improving the likelihood that wetland revegetation will occur. Particular attention will be given to ensuring that appropriate elevations are maintained at sites AA and AB. The plan envisions that site KS will be restored as a lower elevation wetland.

Alternative 5C incorporates the concept of on site remediation and off site mitigation. Although on site wetlands will be lost, preservation or restoration of similar habitat in the region will be accomplished. The wetland areas that are capped under this alternative will be revegetated with plants providing upland wildlife habitat.

7.5.3 Environmental Protection. Both restoration alternatives will provide adequate environmental protection. Restoration options provide the greatest overall level of environmental protection. On site restoration provides a greater level of protection than mitigation since a large part of the contamination will be removed rather than merely covered.

7.5.4 Implementability/Reliability. The reliability of both on site and off site restoration alternatives will be high. On site restoration provides a slightly higher level of protection because contamination is actually removed from the site. The off site restoration (mitigation) option presents the possibility that on site remediation activities will fail. Enforcement of regulations protecting the endangered salt marsh harvest mouse may require trapping and safe removal of a specified number of individuals prior to excavation of contaminated material. Once the wetland is restored, other individuals may be trapped elsewhere and released at NWS Concord to recolonize the site.

There are no apparent insurmountable construction problems associated with implementation of the restoration alternatives. Any problems can be addressed during the concept development or preliminary design phases. Public and regulatory concern will probably be raised because of the proposed activities in wetland areas. A detailed wetland restoration plan will be prepared to partially offset these concerns. Regulatory approval will be required for implementation of these alternatives.

Implementation of the off site mitigation alternative may be difficult if suitable land is not available in the region.

7.5.5 Summary. Three concepts for restoration or enhancement were initially considered. Each restoration alternative appears to provide substantial environmental improvement. Alternative 5A, however, will require from 5-10 years before complete wetland restoration is accomplished. This is considered to be unacceptable. Therefore, only alternative 5B and 5C will be carried forward for detailed evaluation.

## 8.0 ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

The seven alternatives selected for detailed analysis were evaluated and compared on the basis of nine key criteria.

- a. Reliability
- b. Implementability
- c. Technical Effectiveness
- d. Environmental Concerns
- e. Safety
- f. Operation and Maintenance
- g. Costs
- h. Regulatory Requirements
- i. Public Acceptance

### 8.1 Non Cost Criteria Analysis

A discussion of the non cost evaluation criteria as related to the expected advantages and disadvantages of each alternative is presented below.

#### 8.1.1 Reliability

The reliability of each alternative is assessed on the basis of the impact of failure of the alternative.

Alternative 1. Alternative 1, the No Action Alternative, is limited to the posting of contaminated areas and property records to ensure notification of persons that could potentially be exposed to contaminants. Failure of



Alternative 1 would result in an increased probability of persons coming into direct contact with the contaminated materials. There also be the potential for unknowing development or use of contaminated areas with a resultant spread of contaminants.

Alternative 2. Alternative 2, Increased Environmental Monitoring, is designed to allow the further identification of contaminant transport mechanisms and the quantification of environmental impacts. In addition, Alternative 2 includes provisions for future positive remedial action, if deemed necessary. Failure of Alternative 2 would eliminate the ability to track changes in contaminant migration. Since Alternative 2 provides no initial positive environmental protection, its success or failure would result in the same impacts as the No Action Alternative (Lee et al. 1986). Data collection for the environmental monitoring program should be very reliable; however, data interpretations and analysis will be less reliable and subject to significant uncertainty.

Alternative 3. Alternative 3, Excavation and Off Site Disposal, is the most reliable remediation alternative developed for the NWS Concord. The potential for system failure is essentially removed because the hazardous substances are transported off site. There is some potential for leaving unidentified "hot spots" of contamination of site, however, it is anticipated that this would be unlikely. This possibility is addressed by the proposed five year monitoring program.

Alternative 4A. Alternative 4A, Surface Treatment-Topsoil Cover, is designed to minimize the potential for release of contamination through surface water and wind erosion. The potential for direct human or animal contact with contaminated soil material will also be eliminated. Plant contact will be minimized by planting shallow rooted vegetation. Assuming adequate design development, it is unlikely that the proposed cover would fail in the near term (30-50 years) in such manner that the site would be exposed to surface phenomenon. Minor erosion, however, may occur and will be addressed by the proposed site maintenance program. Failure of the cap would result in the continued migration of contaminants, however, at a significantly reduced rate from the No Action Alternative.

Alternative 4B. Alternative 4B, Surface Treatment-Multilayered Cover, is designed to minimize the potential for release of contamination via surface water or wind erosion; direct human, animal, or vegetative contact; and infiltration of surface water through the contaminated soil material. Complete failure of a properly designed and constructed multilayered cover (RCRA cap) is unlikely in the near term. Failure, if any, would probably take the form of minor erosion. This potential is addressed through implementation of the site maintenance program. The proposed environmental monitoring program will facilitate early detection of continued contaminant migration.

Alternative 5B. Alternative 5B, Restoration of On Site Areas, is based on the implementation of Alternative 3A with added emphasis on the restoration of contaminated wetlands. The reliability characteristics of Alternative 5B will be essentially the same as Alternative 3A. However, Alternative 5B may be slightly more reliable because of the increased attention given to site AA on parcel 572 because of the restoration efforts.

Alternative 5C. Alternative 5C, On Site Remediation-Off Site Mitigation, is based on the implementation of Alternative 4A with set aside of off site areas to mitigate the loss of wetland habitat resulting from the construction of the topsoil cover. The reliability characteristics of Alternative 5C will be essentially the same as Alternative 4A.

#### 8.1.2 Implementability

Alternative 1. There are no special implementation problems associated with Alternative 1.

Alternative 2. Theoretically speaking, there are no special problems associated with implementation of Alternative 2. Practically, however, there will be problems associated with the interpretation of environmental data and quantification of action levels that would be used to trigger future remedial actions. These action levels must be quantified in the detailed implementation plan.

Alternative 3. Implementability questions associated with Alternative 3A include: the location of final waste disposal sites, the feasibility of excavating wetland areas, the problem of safely transporting large quantities of contaminated soil material via public rights of way, and successful revegetation of upland and wetland areas. None of these potential problems is believed to represent significant impediments to implementation of the Alternative. Each problem area will be addressed in detail during the concept design phase.

Alternative 4A. Implementability questions associated with Alternative 4A include: the location of suitable fill material for cover construction, the structural stability of the cover in both wetland and upland areas, feasibility of construction in wetland areas, and development of an adequate cover maintenance program. None of these potential problem areas is believed to represent a significant impediment to implementation of Alternative 4A and each can be adequately addressed during the concept design phase.

Alternative 4B. Implementability question associated with Alternative 4B include those associated with Alternative 3A plus the location of suitable fill materials for the multilayered cap. These concerns will be addressed during the concept design phase and are not believed to be a significant impediment to implementation of Alternative 4B.

Alternative 5B. Implementability questions associated with Alternative 5B include those associated with Alternative 3A plus the successful implementation of a wetland restoration and faunal replacement program. These concerns will be addressed during the concept design and are not believed to be a significant impediment to implementation of Alternative 5B.

Alternative 5C. Implementability questions associated with Alternative 5C include those associated with Alternative 4A plus the location of available off site wetland areas (otherwise subject to development) for mitigation of on site wetland losses.

### 8.1.3 Technical Effectiveness

The technical effectiveness of each alternative is evaluated in terms of anticipated ability to meet the environmental protection goal. An additional evaluation factor is the typical performance range for the various components within a proposed alternative.

Alternative 1. Alternative 1 does not meet the selected environmental protection goal or standards.

Alternative 2. Alternative 2 does not meet the selected environmental protection goal. Alternative 2 offers no environmental protection beyond that occurring under current conditions. However, Alternative 2 will allow the continued characterization of the environment around the contaminated sites and the identification of major changes in contaminant migration patterns or potential environmental damage.

Alternative 3A. Alternative 3A provides for removal of contaminated soil material from the sites. Alternative 3A is the most effective remedy for long term remediation of the contaminated areas. Alternative 3A does not remove some low level contaminants that have migrated into areas surrounding the major areas of contamination. Alternative 3A can successfully address the first element of the environmental protection goal, i.e. "minimize or eliminate the continued release and potential release of hazardous substances." However, there are substantial impacts to important wildlife habitat. The recovery of wetlands affected by the remedial action activities may be uncertain.

Alternative 4A. Alternative 4A is designed to prevent further migration of contaminants along surface pathways. Given adequate maintenance, Alternative 4A can meet the first element of the environmental protection goal, i.e. "minimize or eliminate the continued release and potential release of hazardous substances." However, this is accomplished with the loss of over 45 acres of wetland and important habitat for an endangered species.

Alternative 4B. Alternative 4B is designed to prevent further migration of contaminants along surface pathways plus limit the potential for leaching of contaminants into the groundwater. Alternative 4B will be technically efficient for meeting these elements of the environmental protection goal; however, this is accomplished with the loss of over 45 acres of wetland and important habitat for an endangered species.

Alternative 5B. Alternative 5B includes the design features found in Alternative 3A plus wetland restoration. Alternative 5B can meet the environmental protection goal.

Alternative 5C. Alternative 5C includes the design features found in Alternative 4A plus the mitigation of on site wetland loss by set aside off site wetland. Alternative 5C meets an environmental protection goal of preventing migration of contaminants.

#### 8.1.4 Environmental Concerns

Alternative 1. Environmental impacts associated with Alternative 1 are fully discussed in Lee, et al. (1986). It might be postulated that a no action alternative might result in the environment recovering from the release of contaminants, such that concentrations of contaminants decrease with time. This might be true in the case where small amounts of hazardous materials are released. However, this is not the case at NWS Concord where large quantities of heavy metals have been released and spread by wind and surface water action into both upland and wetland area. Damage to native vegetation has been documented (Lee et al. 1985). Heavy metals have migrated into plants and soil invertebrates on site and threaten food chains for endangered species that inhabit NWS Concord (Lee et al. 1986).

Alternative 2. Environmental impacts associated with Alternative 2 are the same as those associated with the no action alternative. Alternative 2 will enable the monitoring of environmental changes; however, it is anticipated that monitoring will merely confirm the continued migration of heavy metals into plants and animals. The contamination will continue to be released into the food chain for a substantial number of years into the

future. More wide spread contamination of wildlife and endangered species should be observed.

Alternative 3A. Long term environmental concerns associated with the offsite migration of contaminants by either surface or ground water pathways will be eliminated if Alternative 3A is implemented. Alternative 3A, however, will present several short term adverse environmental impacts that may be regarded as moderate to severe. These impacts are associated with the major construction operations required for implementation of Alternative 3A. Major short term impacts include:

a. Increased dispersion of contaminated particulates through the air or surface water during the construction effort.

b. Destruction of up to 45 acres of wetlands (in the long term these are expected to recover); and

c. Exposure of off site populations to contaminated soil material.

These short term impacts can be mitigated but not eliminated.

Alternative 4A. Positive impacts include the prevention of further off site migration of contaminants through surface pathways. However, this is achieved with the permanent loss of approximately 45.32 acres of wetland in AA, AB, and KS which will be filled with the cover. There are also short term adverse impacts including a release of materials to the air migration pathways (fugitive dust) and a temporary increase in sediment loads during construction. These impacts can be mitigated by appropriate construction practices.

Alternative 4B. Alternative 4B has the same environmental concerns as Alternative 4A.

Alternative 5B. Alternative 5B has the same short term environmental concerns as Alternative 3A. However, potential concern for wetland recovery is minimized because of the extensive wetland restoration plan proposed in Alternative 5B.

Alternative 5C. Alternative 5C has the same short and long term environmental concerns as Alternative 4B. However, potential concern for wetland loss is somewhat offset by the proposed off site mitigation.

#### 8.1.5 Safety

Alternative 1. There are no additional safety risks to on or off site personnel caused by the implementation of Alternative 1. However, persons entering the posted areas should wear protective clothing and respiratory protection to eliminate the risk of exposure to contaminants.

Alternative 2. Minimal additional safety risks to on and off site personnel will be caused by the implementation of Alternative 2. These risks will be associated with the additional site monitoring which necessitates the personnel go on site. This additional risk is considered to be minimal because of the limited duration of site inspections.

Alternative 3A. Because of the materials known to be present at the sites, there will be a moderate short term safety risk to on and off site personnel during the excavation and transportation of the wastes. Respiratory hazards will be the primary concern during the excavation and transportation process. The normal hazards associated with a large earth moving project will also be encountered.

Alternative 4A. Implementation of Alternative 4A will result in a short term safety risk associated with the possibility of direct contact with exposed contaminated materials. These risks are expected to be minimal. The normal hazards associated with a large earth moving project will also be a concern.

Alternative 4B. The safety risks associated with Alternative 5 are essentially the same as associated with Alternative 4A.

Alternative 5B. The safety risks associated with Alternative 5B are essentially the same as associated with Alternative 3A.

Alternative 5C. The safety risks associated with Alternative 5C are essentially the same as associated with Alternative 4B.

#### 8.1.6 Operation and Maintenance

Operation and maintenance requirements of the various alternatives are evaluated in terms of the major operations and maintenance tasks and their costs. Consideration of costs are presented in Section 8.2.

Alternative 1. Operation and maintenance tasks for Alternative 1 include:

- a. Annual notification plan update;
- b. Annual site inspections; and
- c. Annual site report.

Alternative 2. Operation and maintenance tasks for Alternative 2 include:

- a. Bi-annual soil sampling;
- b. Annual site inspections including surface water sampling, air sampling, and wildlife studies; and
- c. Bi-annual reports.

Alternative 3A. Operation and maintenance tasks for Alternative 3A include:

- a. Site maintenance for 5 years;
- b. Annual environmental monitoring for 5 years; and
- c. Annual reports for 5 years.



Alternative 4A. Operation and maintenance tasks for Alternative 4A include:

- a. Maintenance of the topsoil cover;
- b. Annual site inspections;
- c. Annual environmental monitoring; and
- d. Annual reports.

Alternative 4B. Operation and maintenance tasks for Alternative 4B include:

- a. Maintenance of multilayered cover;
- b. Annual site inspections;
- c. Annual environmental monitoring; and
- d. Annual reports.

Alternative 5B. Operation and maintenance tasks for Alternative 5B include:

- a. Site and wetland restoration maintenance for 5 years;
- b. Annual site inspections for 5 years;
- c. Annual environmental monitoring for 5 years; and
- d. Annual reports for 5 years.

Alternative 5C. Operation and maintenance tasks for Alternative 5C include:

- a. Maintenance of topsoil cover;
- b. Annual on and off site inspection;
- c. Annual environmental monitoring for 5 years with bi-annual monitoring thereafter; and
- d. Annual report.

#### 8.1.7 Regulatory Requirements

Regulatory requirements are important since they can determine the acceptability of a remedial action and may significantly impact the cost of implementation. While remedial alternatives are not required to comply with RCRA, it is desirable that at least one alternative meet the technical requirements of RCRA.

Alternative 1. No significant regulatory requirements are associated with implementation of Alternative 1.

Alternative 2. No significant regulatory requirements are associated with implementation of Alternative 2. However, coordination with appropriate wildlife conservation agencies may be appropriate.

Alternative 3A. Major regulatory requirements impacting Alternative 3A include:

- a. Resource Conservation and Recovery Act (RCRA);
- b. Rivers and Harbors Act;
- c. The Clean Water Act;
- d. The Endangered Species Act; and
- e. Department of Transportation Regulations.

RCRA regulations impact the final disposal of the contaminated soil material. Transportation of contaminated soil material must comply with RCRA and DOT regulations. Construction in wetlands will require permits under the Rivers and Harbors Act and The Clean Water Act.

Alternative 4A. Major regulatory requirements impacting Alternative 4A include:

- a. Resource Conservation and Recovery Act;
- b. Rivers and Harbors Act;
- c. The Clean Water Act; and
- d. The Endangered Species Act.

Alternative 4B. Major regulatory requirements impacting Alternative 4B are the same as those associated with Alternative 4A.

Alternative 5B. Major regulatory requirements impacting Alternative 5B are the same as those associated with Alternative 3A.

Alternative 5C. Major regulatory requirements impacting Alternative 5C are the same as those associated with Alternative 4B.

#### 8.1.8 Public Acceptance

The public acceptance criteria addresses the concerns of the public over implementation of remedial actions. Public acceptance may have a major impact on the implementability of a specific alternative.

Alternative 1. A no action alternative for NWS Concord is likely to be viewed unfavorably by the public.

Alternative 2. Although Alternative 2 provides for increased environmental monitoring, no attempt is made to prevent future migration of

contaminants. The public may perceive Alternative 2 as an extension of the no action alternative which is likely to be unfavorably received.

Alternative 3A. Alternative 3A includes the excavation and transportation of contaminated materials through public rights of way. The public will be unavoidably exposed to the hazardous materials during the transportation process. It is anticipated that significant public reaction, including protests and potential legal action, to Alternative 3A will be generated. As a result, Alternative 3A is expected to be in the one of the more difficult alternatives to implement from a public acceptance viewpoint. It is further expected that significant public education and relations programs will be required to ensure public acceptance of Alternative 3A.

Alternative 4A. Since implementation of Alternative 4A results in the loss of wetland habitat, there may be some public acceptance problems. These problems may be off set by public education and implementation of a public awareness program. It may also be desirable to include the public in the alternative selection process. If the public perceives that loss of wetland habitat presents an unacceptable environmental cost, more extensive remedial actions (Alternative 3A, 5A, or 5B) may be required.

Alternative 4B. Implementation of Alternative 4B will result in the same public acceptance concerns as Alternative 4A.

Alternative 5B. Implementation of Alternative 5B will result in the same public acceptance concerns as Alternative 3A. These may be off set if the public gives a high value to the wetland restoration effort.

Alternative 5C. Implementation of Alternative 5C will result in the same public acceptance concerns as Alternative 4A. These concerns should be off set by the proposed off site mitigation effort.

## 8.2 Cost Analysis

The cost estimates presented in this section are based on second quarter 1985 costs in the San Francisco Bay area. The costs include contractor profit

and overhead. A long term inflation rate of 6.0 percent and long term interest rate of 12.0 percent are used to formulate the appropriate discount rates. Present worth is calculated using a 6 percent real interest rate compounded annually. Operation and maintenance is assumed to last indefinitely unless otherwise noted. In addition, the following general assumptions were made in preparing the cost estimates.

- a. All required utilities will be readily available at the site.
- b. Access to the site will be available.
- c. Sufficient qualified labor is available.
- d. Construction will be conducted in a normal fashion, i.e., 40 hour work week, no scheduled shift work, and a twelve month construction year.
- e. Additional land will be available, if required.
- f. Taxes (local, state, and federal), purchase of heavy equipment, and environmental permitting costs are excluded.
- g. A contingency factor of 25 percent will be added to all construction costs.
- h. Engineering and design, testing and services during construction are included as an add on 15 percent.
- i. Mobilization/demobilization will be added at the rate of 10 percent of construction costs.
- j. A 30 percent productivity penalty is added to unit costs to reflect the nature of the material being handled.

A significant assumption that impacts the cost of the excavation alternatives (3A and 5B) is the required disposal method. It is assumed that all excavated material will require disposal in a RCRA standard disposal facility. Some materials may be suitable for other means of disposal. The cost of material disposals should be evaluated in detail during the concept development phase.

A summary of unit costs used in preparing the alternative cost estimates is presented in Table 8.1.

Table 8.1  
Summary of Unit Costs

<u>Item Description</u>	<u>Unit of Measure</u>	<u>Unit Cost (\$)</u>
Dry excavation	CY	4.20
Wet excavation	CY	8.40
Site grading and revegetation	SY	1.30
Backfilling with clean soil	CY	20.25
Impermeable Seal(less topsoil)	SY	25.63
Wetland restoration	SY	2.25
Land cost (mitigation)	Acre	10,000.
Waste transport (offsite)	CY (loose)	3.00
Site grading (less revegetation)	SY	0.90
Disposal cost (commercial RCRA)	CY (loose)	125.00
Top soil cover (in-place)	CY	25.00
RCRA landfill	CY (loose)	50.00
Sanitary landfill	CY (loose)	30.00
Fencing	LF	10.00

CY: Cubic Yard  
SY: Square Yard  
LF: Linear Foot

#### 8.2.1 Cost of Alternative 1

The capital costs for Alternative 1 are presented in Table 8.2. Operation and maintenance costs are presented in Table 8.3.

The present value by contaminated site of Alternative 1 is presented in Table 8.4.

#### 8.2.2 Cost of Alternative 2

The capital costs for Alternative 2 are limited to those initial costs involved in preparing the detailed sampling and analysis program and development of the action levels and response plan. Obviously, no cost can be allocated at this time for future unknown responses. The capital costs for Alternative 2 are presented in Table 8.5.

Operation and maintenance costs are presented in Table 8.6. The estimates presented are for conduct of Phase 1 and 2 studies on 100 soil samples collected from the eight parcels identified as being contaminated. The cost presented should be conservative estimate of costs since Phase 2 testing will probably not be required on all samples.

The present values by contaminated site of Alternative 2 is presented in Table 8.7.

#### 8.2.3 Cost of Alternative 3A

Estimated capital costs for Alternative 3A are presented in Table 8.8. Estimated operation and maintenance costs are presented in Table 8.9. The estimated present value by contaminated site of Alternative 3A is presented in Table 8.10.

#### 8.2.4 Cost of Alternative 4A

The capital costs associated with Alternative 4A are presented in Table 8.11. The operation and maintenance costs associated with

Table 8.2

Estimated Capital Cost for Alternative 1

Item Number	Item Description	Capital Cost By Area (000\$)						Total
		ES	G1	K2	KS	CP	AA&AB	
1	Develop Notification Plan	1	1	4	4	2	15	27
2	Property Record Review and Annotation	1	1	2	2	1	9	16
3	Property Posting	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>5</u>	<u>12</u>
	Subtotal	3	3	7	8	5	29	55
	Contingency (25%)	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>8</u>	<u>16</u>
	TOTAL	<u>4</u>	<u>4</u>	<u>9</u>	<u>10</u>	<u>7</u>	<u>37</u>	<u>71</u>

Table 8.3

Estimated Operation and Maintenance Costs for Alternative 1

Item Number	Item Description	Operation and Maintenance Cost						
		By Area (000\$/yr) <sup>1</sup>						Total
		ES	G1	K2	KS	CP	AA&AB	
1	Maintenance of Notification Plan	1	1	1	1	1	1	6
2	Annual Site Report	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>6</u>
3	Subtotal	2	2	2	2	2	2	12
4	Contingency (25%)	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>6</u>
	TOTAL	<u>3</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>18</u>

<sup>1</sup> Cost of operation and maintenance allocated by acreage and rounded to next higher \$1,000.



Table 8.4

Estimated Present Value by Contaminated Area for Alternative 1

Contaminated Site	Capital Cost (000\$)	Operation and <sup>1</sup> Maintenance Cost (000\$/yr)	Present Worth <sup>2</sup> Cost (000\$)
ES	4	3(3)	50
G1	4	3(3)	50
K2	9	3(3)	55
KS	10	3(3)	56
CP	7	3(3)	53
AA&AB	37	3(3)	83

<sup>1</sup> ( ) indicates O&M cost for year 6-30.

<sup>2</sup> Rounded to nearest \$1,000.

Table 8.5  
Estimated Capital Cost for Alternative 2

Item Number	Item Description	Capital Cost By Area (000\$)						Total
		ES	G1	K2	KS	CP	AA&AB	
1	Property Records Review and Annotation	1	1	2	2	1	9	16
2	Develop Notification Plan	1	1	4	4	2	15	27
3	Property Posting	1	1	1	2	2	5	12
4	Detailed Sampling and Analysis Plan	1	1	4	4	2	15	27
5	Action Level and Response Plan	<u>4</u>	<u>4</u>	<u>13</u>	<u>16</u>	<u>7</u>	<u>58</u>	<u>102</u>
	Subtotal	8	8	24	28	14	102	184
	Contingency (25%)	<u>2</u>	<u>2</u>	<u>6</u>	<u>7</u>	<u>4</u>	<u>26</u>	<u>47</u>
	TOTAL	<u>10</u>	<u>10</u>	<u>30</u>	<u>35</u>	<u>18</u>	<u>128</u>	<u>231</u>

Table 8.6

Estimated Operation and Maintenance Cost for Alternative 2

Item Number	Item Description	Capital Cost By Area (000\$) <sup>1</sup>						Total
		ES	GI	K2	KS	CP	AA&AR	
1	Part 1 Sampling and Analysis <sup>2</sup>	2	2	2	3	2	9	20
2	Part 2 Sampling and Analysis	11	10	37	43	21	153	275
3	Maintenance of Notification Plan	1	1	1	1	1	1	6
4	Annual Site Report	1	1	1	1	1	1	6
5	Sampling and Analysis Report <sup>2</sup>	1	1	2	3	2	9	18
	Subtotal	16	15	43	51	27	173	325
	Contingency (25%)	4	4	11	13	7	44	83
	TOTAL	20	19	54	64	34	217	408

<sup>1</sup> Cost of operation and maintenance allocated by acreage and rounded to next higher \$1,000.

<sup>2</sup> These activities conducted biannually.

Table 8.7

Estimated Present Value by Contaminated Area for Alternative 2

Contaminated Site	Capital Cost (000\$)	Operation and <sup>1</sup> Maintenance Cost (000\$/yr)	Present Worth Cost (000\$)
ES	10	20(20)	317
G1	10	19(19)	302
K2	30	54(54)	860
KS	35	64(64)	1,019
CP	18	34(34)	541
AA&AB	128	217(217)	3,464

<sup>1</sup> ( ) indicates O&M Cost for year 6-30.

Table 8.8

## Estimated Capital Cost for Alternative 3A

Item Number	Item Description	Capital Cost By Area (000\$)						AA&BB	Total
		ES	GI	K2	KS	CP			
1	Site Preparation	5	5	11	16	5		61	103
2	Excavation	14	11	44	83	24		399	575
3	Backfilling	67	52	214	399	114		961	1809
4	Transportation	14	11	44	83	24		199	375
5	Off Site Disposal	576	452	1852	3452	988		8309	15629
6	Grading and Revegetation	19	15	51	62	29		205	382
7	Subtotal	695	546	2217	4095	1184		10135	18872
8	Mobilization (10%)	69	55	222	409	118		1014	1887
9	Engineering (15%)	104	82	333	614	178		1520	2831
10	Contingency (25%)	173	136	554	1024	296		2534	4718
	Total	1041	819	3326	6142	1777		15203	28307

Table 8.9

## Estimated Operation and Maintenance Cost for Alternative 3A

Item Number	Item Description	Operation and Maintenance Cost by Area (000\$/yr) <sup>1,2</sup>						
		ES	GI	K2	KS	CP	AA&AB	Total
1	Site Maintenance	1	1	3	4	2	12	23
2	Maintenance of Notification Plan	1	1	1	1	1	1	6
3	Part 1 Sampling and Analysis <sup>2</sup>	2	2	2	3	2	9	20
4	Part 2 Sampling and Analysis	11	10	37	43	21	153	275
5	Annual Site Report	1	1	1	1	1	1	6
6	Sampling and Analysis Report <sup>2</sup>	1	1	2	3	2	9	18
	Subtotal	17	16	46	55	29	185	348
	Contingency (25%)	5	4	12	14	8	47	90
	Total	22	20	58	69	37	232	438

<sup>1</sup> Cost of operation and maintenance allocated by acreage and rounded to next higher \$1,000.

<sup>2</sup> All operation and maintenance discontinued after five (5) years.

<sup>3</sup> These activities conducted biannually.

Table 8.10

Estimated Present Value by Contaminated Area for Alternative 3A

Contaminated Site	Capital Cost (000\$)	Operation and <sup>1</sup> Maintenance Cost (000\$/yr)	Present Worth <sup>2</sup> Cost (000\$)
ES	1,041	22(0)	1,058
G1	819	20(0)	835
K2	3,326	58(0)	3,371
KS	6,142	69(0)	6,196
CP	1,777	37(0)	1,806
AA&AB	15,203	232(0)	15,385

<sup>1</sup> ( ) indicates O&M Cost for year 6-30.  
<sup>2</sup> Rounded to nearest \$1,000.

Table 8.11  
Estimated Capital Cost for Alternative 4A

Item Number	Item Description	Capital Cost By Area (000\$)						Total
		ES	G1	K2	KS	CP	AA&BB	
1	Site Preparation	5	5	11	16	5	61	103
2	Initial Site Grading	7	5	22	28	12	100	174
3	Clean Fill Cover	142	113	445	551	241	1957	3448
4	Top Soil Cover	266	221	702	848	412	2726	5174
5	Final Grading and Revegetation	21	17	55	66	32	213	404
6	Subtotal	441	361	1235	1509	701	5056	9303
7	Mobilization (10%)	44	36	123	151	70	506	930
8	Engineering (15%)	66	54	185	226	105	758	1395
9	Contingency (25%)	110	90	309	377	175	1264	2326
	Total	662	541	1852	2263	1052	7584	13955



Alternative 4A are presented in Table 8.12. The present value by contaminated site of Alternative 4A is presented in Table 8.13.

#### 8.2.5 Cost of Alternative 4B.

The capital costs associated with implementation of Alternative 4B are presented in Table 8.14. Operation and maintenance are presented in Table 8.15.

The present value by contaminated site of Alternative 4B is presented in Table 8.16.

#### 8.2.6 Cost of Alternative 5B.

The capital costs associated with Alternative 5B are presented in Table 8.17. Operation and maintenance costs of Alternative 5B are presented in Table 8.18.

The estimated present value by contaminated site of Alternative 5B is presented in Table 8.19.

#### 8.2.7 Cost of Alternative 5C.

The capital costs associated with Alternative 5C are presented in Table 8.20. The operation and maintenance costs associated with Alternative 5C are presented in Table 8.21. The present worth by contaminated site of Alternative 5C is presented in Table 8.22.

#### 8.2.8 Summary of Costs.

A summary of costs for the proposed remedial action alternatives is presented in Table 8.23.

Table 8.12

## Estimated Operation and Maintenance Cost for Alternative 4A

Item Number	Item Description	Operation and Maintenance Cost by Area (000\$/yr) <sup>1,2</sup>						
		ES	G1	K2	KS	CP	AA&AB	Total
1	Cover Inspection and Maintenance	1(1)	1(1)	4(2)	4(2)	2(1)	15(6)	27(13)
2	Maintenance of Notification Plan	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	6(6)
3	Part 1 Sampling and Analysis <sup>3</sup>	2(1)	2(1)	2(1)	3(2)	2(1)	9(5)	20(11)
4	Part 2 Sampling and Analysis	11(6)	10(5)	37(19)	43(22)	21(11)	153(77)	275(140)
5	Sampling and Analysis Report <sup>3</sup>	1(1)	1(1)	2(1)	3(2)	2(1)	9(5)	18(11)
6	Annual Site Report	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	6(6)
	Subtotal	17(11)	16(10)	47(25)	55(30)	29(16)	188(95)	352(187)
	Contingency (25%)	5(3)	4(3)	12(7)	14(8)	8(4)	47(24)	90(49)
	Total	22(14)	20(13)	59(32)	69(38)	37(20)	235(119)	442(236)

<sup>1</sup> Cost of operation and maintenance allocated by acreage and rounded to next higher \$1,000.

<sup>2</sup> ( ) indicates cost after first 5 years.

<sup>3</sup> These activities conducted biannually.

Table 8.13

Estimated Present Value by Contaminated Area for Alternative 4A

Contaminated Site	Capital Cost (000\$)	Operation and <sup>1</sup> Maintenance Cost (000\$/yr)	Present Worth <sup>2</sup> Cost (000\$)
ES	662	22(14)	834
G1	541	20(13)	700
K2	1,852	59(32)	2,252
KS	2,263	69(38)	2,737
CP	1,052	37(20)	1,302
AA&AB	7,584	235(119)	9,083

<sup>1</sup> ( ) indicates O&M Cost for year 6-30.

<sup>2</sup> Rounded to nearest \$1,000.

Table 8.14

## Estimated Capital Cost for Alternative 4B

Item Number	Item Description	Capital Cost By Area (000\$)						Total
		ES	GI	K2	KS	CP	AA&BB	
1	Site Preparation	5	5	11	16	5	61	103
2	Initial Site Grading	7	5	22	28	12	100	174
3	Impermeable Seal	365	299	1007	1225	578	4048	7522
4	Top Soil Cover	292	244	743	894	444	2807	5425
5	Final Grading and Revegetation	23	19	58	70	35	219	423
6	Subtotal	692	572	1841	2232	1073	7235	13646
7	Mobilization (10%)	69	57	184	223	107	724	1365
8	Engineering (15%)	104	86	276	335	161	1085	2047
9	Contingency (25%)	173	143	460	558	268	1809	3411
	Total	1038	859	2762	3348	1610	10853	20469

Table 8.15

## Estimated Operation and Maintenance Cost for Alternative 4B

Item Number	Item Description	Operation and Maintenance Cost by Area (000\$/yr) <sup>1,2</sup>						
		ES	G1	K2	KS	CP	AA&AB	Total
1	Cover Inspection and Maintenance	2(1)	1(1)	4(2)	5(3)	3(2)	18(9)	33(18)
2	Maintenance of Notification Plan	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	6(6)
3	Part 1 Sampling and Analysis <sup>3</sup>	2(1)	2(1)	2(1)	3(2)	2(1)	9(5)	20(11)
4	Part 2 Sampling and Analysis	11(6)	10(5)	37(19)	43(22)	21(11)	153(77)	275(140)
5	Sampling and Analysis Report <sup>3</sup>	1(1)	1(1)	2(1)	3(2)	2(1)	9(5)	18(11)
6	Annual Site Report	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	6(6)
	Subtotal	18(11)	16(10)	47(25)	56(31)	30(17)	191(98)	358(192)
	Contingency (25%)	5(3)	4(3)	12(7)	14(8)	8(5)	48(25)	91(51)
	Total	23(14)	20(13)	59(32)	70(39)	38(22)	239(123)	449(243)

<sup>1</sup> Cost of operation and maintenance allocated by acreage and rounded to next higher \$1,000.

<sup>2</sup> ( ) indicates cost after 5 years.

<sup>3</sup> These activities conducted biannually.

Table 8.16

Estimated Present Value by Contaminated Area for Alternative 4B

Contaminated Site	Capital Cost (000\$)	Operation and <sup>1</sup> Maintenance Cost (000\$/yr)	Present Worth <sup>2</sup> Cost (000\$)
ES	1,038	23(14)	1,211
G1	859	20(13)	1,018
K2	2,762	59(32)	3,162
KS	3,348	70(39)	3,834
CP	1,610	38(22)	1,883
AA&AB	10,853	239(123)	12,399

<sup>1</sup> ( ) indicates O&M Cost for year 6-30.  
<sup>2</sup> Rounded to nearest \$1,000.

Table 8.17  
Estimated Capital Cost for Alternative 5B

Item Number	Item Description	Capital Cost By Area (9000\$)							Total
		ES	G1	K2	KS	CP	AA&BR		
1	Site Preparation	5	5	11	16	5	61	103	
2	Initial Site Grading	-	-	-	-	12	-	12	
	Excavation	14	11	44	83	-	399	551	
	Backfilling	-	-	-	399	-	961	1360	
	Transportation	14	11	44	83	-	199	351	
	Off Site Disposal	576	452	1852	3452	-	8309	14641	
	Clean Fill Cover	-	-	-	-	241	-	241	
	Top Soil Cover	-	-	-	-	412	-	412	
	Final Grading	13	10	35	43	30	142	273	
	Revegetation	6	5	16	-	9	-	36	
	Wetland Restoration	-	-	-	108	-	355	463	
	Subtotal	628	494	2002	4184	709	10426	18443	
	Mobilization (10%)	63	50	200	418	70	1043	1844	
	Engineering (15%)	94	74	300	627	106	1564	2765	
	Contingency (25%)	157	124	500	1046	177	2606	4610	
	Total	942	742	3002	6275	1062	15639	27662	

Table 8.18  
Estimated Operation and Maintenance Cost for Alternative 5B

Item Number	Item Description	Operation and Maintenance Cost by Area (000\$/yr) <sup>1,2</sup>						Total
		ES	GI	K2	KS	CP	AA&AB	
1	Site Maintenance	1	1	3	4	2	31	42
2	Maintenance of Notification Plan	1	1	1	1	1	1	6
3	Part 1 Sampling and Analysis	2	2	2	3	2	9	20
4	Part 2 Sampling and Analysis	11	10	37	43	21	153	275
5	Sampling and Analysis Report	1	1	2	3	2	9	18
6	Annual Site Report	1	1	1	1	1	5	10
	Subtotal	17	16	46	55	29	185	348
	Contingency (25%)	5	4	12	14	8	47	90
	Total	22	20	58	69	37	232	438

- 1 Cost of operation and maintenance allocated by acreage and rounded to next higher \$1,000.
- 2 All operation and maintenance for this alternative discontinued after 5 years.



Table 8.19

Estimated Present Value by Contaminated Area for Alternative 5B

Contaminated Site	Capital Cost (000\$)	Operation and <sup>1</sup> Maintenance Cost (000\$/yr)	Present Worth <sup>2</sup> Cost (000\$)
ES	942	22(0)	959
G1	742	20(0)	758
K2	3,002	58(0)	3,047
KS	6,275	69(0)	6,329
CP	1,062	37(0)	1,091
AA&AB	15,639	232(0)	15,821

<sup>1</sup> ( ) indicates O&M Cost for year 6-30.  
<sup>2</sup> Rounded to nearest \$1,000.

Table 8.20  
Estimated Capital Cost for Alternative 5C

Item Number	Item Description	Capital Cost By Area (000\$)						Total
		ES	G1	K2	KS	CP	AA&BB	
1	Site Preparation	5	5	11	16	5	61	103
2	Initial Site Grading	7	5	22	28	12	100	174
3	Clean Fill Cover	142	113	445	551	241	1957	3448
4	Top Soil Cover	266	221	702	848	412	2726	5174
5	Final Grading and Revegetation	21	17	55	66	32	213	404
6	Off Site Mitigation Lands	-	-	-	105	-	348	453
7	Wetland Restoration of Off Site Lands	-	-	-	115	-	368	483
8	Subtotal	441	361	1235	1729	701	5772	10239
9	Mobilization (10%)	44	36	123	173	70	577	1024
10	Engineering (15%)	66	54	185	259	105	866	1536
11	Contingency (25%)	110	90	309	432	175	1443	2560
	Total	662	541	1852	2593	1052	8658	15358

Table 8.21

## Estimated Operation and Maintenance Cost for Alternative 5C

Item Number	Item Description	Operation and Maintenance Cost by Area (000\$/yr)						
		ES	GI	K2	KS	CP	AA&AB	Total
1	Cover Inspection and Maintenance	1(1)	1(1)	4(2)	4(2)	2(1)	15(6)	27(13)
2	Maintenance of Notification Plan	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	6(6)
3	Part 1 Sampling and Analysis-On Site	2(1)	2(1)	2(1)	3(2)	2(1)	9(5)	20(11)
4	Part 2 Sampling and Analysis-On Site	11(6)	10(5)	37(19)	43(22)	21(11)	153(77)	275(140)
5	Sampling and Analysis Report-On Site	1(1)	1(1)	2(1)	3(2)	2(1)	9(5)	18(11)
6	Annual Site Report	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	6(6)
7	Restored Wetland Maintenance <sup>1</sup>	-	-	-	50(0)	-	150(0)	200(0)
	Subtotal	17(11)	16(10)	47(25)	105(30)	29(16)	338(95)	552(187)
	Contingency (25%)	5(3)	4(3)	12(7)	27(8)	8(4)	85(24)	141(49)
	Total	22(14)	20(13)	59(32)	132(38)	37(20)	423(119)	693(236)

<sup>1</sup> Includes off site monitoring program. Off site maintenance and monitoring is discontinued after 5 years.

Table 8.22

Estimated Present Value by Contaminated Area for Alternative 5C

Contaminated Site	Capital Cost (000\$)	Operation and <sup>1</sup> Maintenance Cost (000\$/yr)	Present Worth Cost (000\$)
ES	662	22(14)	834
G1	541	20(13)	700
K2	1,852	59(32)	2,252
KS	2,593	132(38)	3,116
CP	1,052	37(20)	1,302
AA&AB	8,658	423(119)	10,304

<sup>1</sup> ( ) indicates O&M Cost for year 6-30.

Table 8.23

Summary of Costs for Alternative Remedial Actions at NWSC Concord<sup>1</sup>

Alternative	Site ES			Site GI			Site K2			Site KS		
	Capital (000\$)	O&M (000\$/ yr)	Present Worth (000\$)	Capital (000\$)	O&M (000\$/ yr)	Present Worth (000\$)	Capital (000\$)	O&M (000\$/ yr)	Present Worth (000\$)	Capital (000\$)	O&M (000\$/ yr)	Present Worth (000\$)
1	4	3	50	4	3	50	9	3	55	10	3	56
2	10	20	317	10	19	302	30	54	860	35	64	1,019
3A	1041	22(0)	1,058	819	20(0)	835	3326	58(0)	3,371	6142	69(0)	6,196
4A	662	22(14)	834	541	20(13)	700	1852	59(32)	2,252	2263	69(38)	2,737
4B	1038	23(14)	1,211	859	20(13)	1,018	2762	59(32)	3,162	3348	70(39)	3,834
5B	942	22(0)	959	742	20(0)	758	3002	58(0)	3047	6275	69(0)	6,329
5C	662	22(14)	834	541	20(13)	700	1852	59(32)	2,252	2593	132(38)	3,116

	Site CP			Site AA&AB			Total		
	Capital (000\$)	O&M (000\$/ yr)	Present Worth (000\$)	Capital (000\$)	O&M (000\$/ yr)	Present Worth (000\$)	Capital (000\$)	O&M (000\$/ yr)	Present Worth (000\$)
1	7	3	53	37	3	83	71	18	348
2	18	34	541	128	217	3,464	231	408	6,503
3A	177	37(0)	1,806	15,203	232(0)	15,385	28,307	438(0)	28,650
4A	1052	37(20)	1,302	7,584	235(119)	9,082	13,955	442(236)	16,907
4B	1610	38(22)	1,883	10,853	239(123)	12,399	20,469	449(243)	23,504
5B	1062	37(0)	1,091	15,639	232(0)	15,821	27,662	438(0)	28,005
5C	1052	37(20)	1,302	8,658	423(119)	10,304	15,358	693(236)	18,507

<sup>1</sup> All present worth values are rounded to nearest \$1,000.

## 9.0 SELECTION OF REMEDIAL ALTERNATIVE

(To Be Published)

## 10.0 ADDITIONAL STUDY REQUIREMENTS

The feasibility study is designed to develop and evaluation, on a preliminary basis, site specific remedial action alternatives. The formulation and evaluation process is based on existing knowledge about a site, which in some cases is rather limited. Although a comprehensive and detailed RI was conducted for NWS Concord, formulation of the remedial action alternatives appropriate at NWS Concord indicates a need to conduct detailed studies of specific concerns associated with each remedial action alternative. The major required additional studies prior to engineering design are summarized below.

10.1 Alternative 1. Implementation of Alternative 1 will require no additional studies.

10.2 Alternative 2. Implementation of Alternative 2 will require the development of a detailed sampling and analysis plan as well as a contingency plan for implementing future remedial actions.

10.3 Alternative 3A. Implementation of Alternative 3A requires the following detailed studies:

- a. Safe methods for excavating contaminated soil material;
- b. Methods for excavating in wetland areas;
- c. Suitable landfill locations for final waste disposal;
- d. Location of suitable backfill material; and
- e. Detailed environmental monitoring and response program.

10.4 Alternative 4A. Implementation of Alternative 4A requires the following detailed studies:

- a. Location of suitable borrow areas for fill and cap materials;

b. Slope stability analyses of the cap; and

c. Detailed environmental monitoring and response program.

10.5 Alternative 4B. Implementation of Alternative 4B requires the following detailed studies:

a. Location of suitable borrow areas for fill and cap materials;

b. Slope stability analyses of the cap; and

c. Detailed environmental monitoring and response program.

10.6 Alternative 5B. Implementation of Alternative 5B requires the following detailed studies:

a. Safe methods for excavating contaminated soil material;

b. Methods for excavating in wetland areas;

c. Suitable landfill locations for final waste disposal;

d. Location of borrow areas for backfill material;

e. Detailed wetland restoration program; and

f. Detailed environmental monitoring program.

10.7 Alternative 5C. Implementation of Alternative 5C requires the following detailed studies:

a. Location of suitable borrow areas for fill and cap materials;

b. Slope stability analyses of the cap;



c. Detailed environmental monitoring and response program; and

d. Identification of off site wetlands to be acquired for mitigation.

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